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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., October 15, 1924.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1924, covering especially those functions of the bureau which are provided for by the act making appropriations for the Department of Agriculture. A brief statement of the work done in connection with the construction of Federal-aid and national-forest roads is also included, but a more complete report of that work will be made in a subsequent report as provided for in section 19 of the Federal highway act, approved November 9, 1921.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

HON. HENRY C. WALLACE,
Secretary of Agriculture.

FEDERAL-AID ROAD CONSTRUCTION

A detailed report of the operations of the bureau in connection with the construction of Federal-aid roads is furnished separately for inclusion in the report to Congress which the Secretary is required to make annually by the Federal highway act. In this report, therefore, it is believed that such detailed information may be omitted, but it will not be inappropriate, perhaps, to review in a general way the progress that has been made, and to refer to a few of the more significant accomplishments of the year.

It is not difficult this year to single out the most important forward step. The final designation and approval of the Federal-aid highway system in all the States of the Union is an event that will be recognized as time goes on as one of the milestones of progress in the improvement of the highways of the country. The map of the system, published November 1, 1923, presents a definite plan for the improvement of the main highways of the Nation—a plan which it is possible to carry out in a period of not more than 10 years, and which, in that limited period, will result in a connected system of arterial highways that will permit unobstructed highway transportation between all cities of 5,000 population or larger. The duty of constructing the connecting roads which are needed to give access to the main system rests with the States and counties.

The Federal highway act of November 9, 1921, which provided for the designation of the system, also provided that within two years a map should be published showing the progress of selection and designation of the system. The map published within the time limit specified represents the required system practically in its entirety. The determination of the mileage of the system, as prescribed by law, was based on the mileage of all existing roads of record in the several State highway departments at the

time of the passage of the act. Each State was asked to certify the mileage of its existing roads according to its records, and the total of certifications amounted to 2,866,061 miles, 7 per cent of which, or 200,624 miles, the law provides may be included in the Federal-aid highway system.

The map issued in November includes 168,881 miles. Subsequently additions were made in several States which increase the total as of June 30, the end of the fiscal year, to 171,687 miles. The original map represents the system of the entire United States on a scale of 1 to 5,000,000. A relatively small edition of it was published for the use of the several State departments and various agencies of the Federal Government. Subsequently, in order to make available a map suitable for more general use, a set of maps consisting of 18 sheets, each sheet comprising a group of States, was published.

ORIGINAL SYSTEM COMPLETED IN THREE STATES

In designating the system in the several States the most important interstate and intercounty roads have been included up to the limit of mileage prescribed by the law, without regard to their state of improvement. A considerable mileage has been included which is already improved, and the magnitude of the task ahead is reduced to that extent.

In three States the original system has already been completed or provided for and, as contemplated by the law, additions to the system in excess of 7 per cent of the total mileage of public highways have been approved by the Secretary as State funds have become available for such extensions. These States are Delaware, Maryland, and Rhode Island. In Delaware the original system, comprising the full 7 per cent of existing total mileage, included 266.84 miles. Completion of this system was recognized by the Secretary on July 17, 1923, at which time the first extensions were approved. In Maryland the original system comprised 1,036.7 miles, and this mileage was completed or provided for and so recognized by the Secretary August 23, 1923, at which time additions were approved. The Rhode Island system of 165.95 miles was reported complete in June, 1924, and acceptance of the system was pending at the close of the fiscal year.

In connection with the completion of the original system in these States it was necessary to consider the condition not only of the Federal-aid projects constructed on the approved system but also all other construction by the State or its political subdivisions. Anticipating the completion of the system in other States, most of which have a much larger mileage, a detailed examination of all roads in the systems of the several States is now under way. The results of the examination are recorded and constitute a complete description of the condition of the entire system. Such descriptions had been completed prior to the close of the fiscal year in Connecticut and Pennsylvania, and were nearly completed in New Jersey. These records will ultimately show in detail the condition of improvement of the entire Federal-aid system, and the work of compiling them will be advanced as rapidly as the administration of the Federal highway act requires.

As this information is secured it is recorded on road maps of the States on a scale sufficiently large to show the improved sections and the nature of each. These maps, together with written descriptions of each improved section, will furnish the most complete collection of road information that has ever been undertaken.

THE IMPROVEMENT OF THROUGH ROADS IN THE WEST

The survey of the status of improvement in the Western States indicates that the part of the system in the 11 Pacific and Mountain States, embracing 31,437 miles, is now more than 50 per cent completed. In these States attention has been given especially to the acceleration of the improvement of through roads to the coast, particularly in Nevada and Utah toward San Francisco. In these States the national need for through east-and-west connection does not in all cases coincide with the highway needs of the locality. This is a situation which is peculiar to the sparsely settled Western States. Elsewhere it is found that the national and local needs are practically identical.

An extensive investigation of various possible routes across the Mohave Desert in California, Nevada, and Arizona has resulted in the selection of routes which will shorten the line of transcontinental travel by 37 miles. A similar study of the route from Salt Lake City to Los Angeles has made possible a reduction in mileage of 88 miles, and it has been found

to be possible to combine these two routes for 103 miles, thus reducing correspondingly the necessary Federal-aid mileage.

PROGRESS OF CONSTRUCTION

As the result of the year's work 8,620 miles have been added to the mileage of completed roads, bringing the total completed since 1916, when the policy of Federal aid was initiated, to 35,157 miles. Work was in progress at the end of the year on 15,350 miles, and these roads were reported as 56 per cent complete in the aggregate.

The total cost of the roads completed during the year was $144,707,337.26, of which $66,789,426.70 was paid by the Federal Government. The total expenditure of Federal-aid funds during the year, including payments made on the completed roads and progress payments on the roads remaining under construction, was $79,217,397.90.

Mileage, total cost, and Federal aid allotted to all Federal-aid roads completed up to June 30, 1924, by States

State	Total cost [1]	Federal aid [1]	Miles
Alabama	$7,517,652.60	$3,645,712.99	671.5
Arizona	8,464,741.67	4,364,912.41	537.7
Arkansas	11,168,854.55	4,459,345.63	948.9
California	17,129,807.90	7,860,406.87	681.4
Colorado	9,624,118.34	4,875,189.66	578.3
Connecticut	3,411,625.09	1,433,498.60	81.8
Delaware	3,479,251.47	1,188,737.33	84.3
Florida	2,959,921.69	1,432,297.39	112.6
Georgia	18,255,751.55	8,485,801.41	1,326.8
Idaho	8,412,287.56	4,233,045.90	526.8
Illinois	30,529,027.07	14,059,816.59	914.2
Indiana	8,851,308.28	4,288,205.02	263.2
Iowa	23,392,465.64	9,323,231.86	1,688.6
Kansas	22,157,546.12	7,727,772.68	657.5
Kentucky	11,240,234.38	4,826,886.37	452.9
Louisiana	8,834,764.36	3,801,223.09	701.1
Maine	7,028,584.03	3,358,698.00	237.0
Maryland	7,001,602.09	3,332,677.06	252.7
Massachusetts	11,218,868.20	4,490,689.22	254.4
Michigan	15,651,440.84	7,167,293.78	573.9
Minnesota	23,990,791.09	9,889,836.27	2,310.2
Mississippi	7,888,193.89	3,828,845.32	655.0
Missouri	12,712,501.43	5,926,010.43	906.1
Montana	8,911,059.55	4,408,281.04	805.7
Nebraska	10,310,188.74	4,909,514.60	1,718.9
Nevada	3,946,723.21	2,324,136.18	282.5
New Hampshire	3,228,323.59	1,554,076.35	176.2
New Jersey	8,266,033.22	2,872,160.02	159.2
New Mexico	6,708,414.96	3,602,488.73	879.6
New York	21,514,710.61	9,286,615.78	627.6
North Carolina	16,828,430.45	7,245,122.17	1,005.1
North Dakota	9,177,593.39	4,464,647.10	1,634.2
Ohio	33,856,447.68	12,110,970.93	984.8
Oklahoma	12,986,865.26	5,888,852.03	497.3
Oregon	12,378,149.70	5,999,884.29	676.2
Pennsylvania	42,432,577.89	16,096,142.29	831.0
Rhode Island	1,952,560.40	841,827.96	49.1
South Carolina	9,278,992.55	4,315,610.91	1,035.6
South Dakota	9,471,954.54	4,703,417.22	1,096.6
Tennessee	7,578,569.06	3,700,378.92	292.1
Texas	42,511,071.15	16,242,423.41	3,161.5
Utah	4,181,049.06	2,463,576.97	317.5
Vermont	1,922,114.16	942,769.12	74.4
Virginia	11,295,753.95	5,390,201.02	620.8
Washington	11,192,478.17	5,231,713.29	469.2
West Virginia	6,171,851.10	2,663,341.02	275.8
Wisconsin	19,078,289.18	7,605,283.33	1,356.8
Wyoming	6,224,847.80	3,152,141.34	712.3
Total	602,326,389.21	261,955,709.90	35,156.9

[1] Figures subject to revision on payment of a few final vouchers now outstanding.

Mileage, total cost, and Federal aid allotted to Federal-aid roads completed during the fiscal year 1924, by States

State	Total cost [1]	Federal aid [1]	Miles
Alabama	$3,498,331.31	$1,735,855.02	281.6
Arizona	1,867,550.18	1,120,842.26	161.1
Arkansas	1,710,491.98	754,273.51	120.7
California	5,966,694.48	2,961,544.12	236.1
Colorado	2,426,060.84	1,340,102.69	119.9
Connecticut	637,077.64	329,349.75	17.2
Delaware	882,552.75	404,957.50	26.6
Florida	1,835,869.96	889,031.97	54.1
Georgia	3,385,611.08	1,670,211.85	313.4
Idaho	1,531,613.83	960,934.89	100.7
Illinois	5,283,778.96	2,628,663.69	169.4
Indiana	2,429,554.75	1,170,062.58	83.6
Iowa	6,708,418.12	2,976,930.45	498.3
Kansas	2,814,977.98	2,221,652.64	197.0
Kentucky	4,091,665.45	1,772,755.66	149.8
Louisiana	774,581.92	354,427.71	51.2
Maine	1,901,381.81	891,784.23	77.0
Maryland	1,486,580.88	709,254.92	60.6
Massachusetts	3,290,325.72	1,221,644.39	64.5
Michigan	4,327,152.21	1,957,761.76	151.5
Minnesota	3,614,442.16	1,612,349.17	379.6
Mississippi	2,119,022.64	1,043,974.35	144.3
Missouri	4,036,079.66	2,002,794.21	357.0
Montana	678,175.29	357,753.90	63.9
Nebraska	2,578,227.83	1,186,018.65	337.8
Nevada	490,595.18	474,163.13	51.7
New Hampshire	804,712.87	391,342.72	34.5
New Jersey	2,257,014.09	709,736.50	37.8
New Mexico	1,449,383.46	861,822.67	179.0
New York	9,357,341.72	4,038,673.77	291.0
North Carolina	3,914,317.99	1,479,048.51	110.2
North Dakota	3,201,497.94	1,562,676.03	668.2
Ohio	8,972,108.94	3,473,067.42	267.7
Oklahoma	2,610,121.38	1,178,008.92	123.8
Oregon	1,830,105.86	1,121,358.05	132.4
Pennsylvania	9,165,681.09	3,396,083.50	174.0
Rhode Island	468,485.05	194,193.00	10.5
South Carolina	2,799,080.27	1,280,643.13	320.6
South Dakota	3,399,339.49	1,726,556.03	417.4
Tennessee	2,101,606.26	1,031,620.82	85.2
Texas	9,488,741.88	3,558,051.67	641.2
Utah	1,482,812.55	869,250.45	139.9
Vermont	551,398.53	273,335.37	21.3
Virginia	3,234,876.38	1,496,941.16	163.9
Washington	835,497.35	412,607.59	49.4
West Virginia	1,636,124.52	651,078.19	52.0
Wisconsin	3,492,543.18	1,569,794.09	265.8
Wyoming	1,287,731.85	764,442.01	165.9
Total	144,707,337.26	66,789,426.70	8,620.3

[1] Figures subject to revision on payment of a few final vouchers now outstanding.

As in previous years, the mileage of gravel roads completed exceeded the mileage of any other type of construction, the year's total including 3,353.8 miles. Other types were completed, as follows: Graded and drained, 1,604.8 miles; sand-clay, 888.2 miles; waterbound macadam, 106.7 miles; bituminous macadam, 566.6 miles; bituminous concrete, 252.1 miles; concrete, 1,667.9 miles; brick, 169.4 miles. Bridges more than 20 feet in span completed during the year aggregated in length 10.8 miles. The mileage of the various types completed during the year and since the initiation of the Federal-aid policy and the mileage by types and by States are shown in the accompanying tables.

Mileage of all Federal-aid roads completed up to June 30, 1924, by types of construction and by States

States	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land ce-ment con-crete	Brick	Bridges	Total
Alabama	3.2	286.7	277.7	11.6	26.6	54.8	9.6		1.3	671.5
Arizona	52.7	55.9	312.6	14.2		9.0	92.3		1.2	537.7
Arkansas			660.0	44.8	29.5	176.4	37.2		1.1	948.9
California	218.8		102.7	7.3	45.6	26.5	279.6		1.0	681.4
Colorado	150.5	67.4	240.8			1.0	116.3		2.2	578.3
Connecticut					27.1		54.7			81.8
Delaware							78.1	6.2		84.3
Florida		21.2			42.1	8.6	30.6	10.1	0.1	112.6
Georgia	58.3	836.9	209.9	22.2	69.8	11.6	103.4	0.3	14.6	1,326.8
Idaho	111.4	18.6	337.5	4.3		33.0	21.3		0.9	526.8
Illinois	135.1		0.4		3.3	8.1	748.7	17.3	1.2	914.2
Indiana	0.5		12.4			12.0	238.0		0.4	263.2
Iowa	1,014.4		344.4				307.9	22.0		1,688.6
Kansas	97.1	16.8	109.8	4.5	28.5		305.1	95.6		657.5
Kentucky	244.6		41.8	38.4	82.0		42.0	3.9	0.2	452.9
Louisiana	7.4		683.0	3.2		7.6				701.1
Maine			101.4		96.1		39.3		0.2	237.0
Maryland	3.8		28.9	0.1	27.3	12.3	180.4			252.7
Massachusetts				3.3	141.0	25.0	84.6		0.5	254.4
Michigan			224.8	18.9		61.5	268.3			573.9
Minnesota	221.0		1,855.9			22.1	210.8		0.3	2,310.2
Mississippi	121.4	14.4	443.5	11.1		3.4	52.0	9.2		655.0
Missouri	202.1		518.9	8.2	38.9	2.8	127.9	5.7	1.5	906.1
Montana	193.2		555.9	16.0	6.9	0.9	31.3		1.6	805.7
Nebraska	1,320.8	163.1	181.5			6.7	34.7	11.9		1,718.9
Nevada	69.9	7.0	153.3		15.6	1.6	34.6		0.5	282.5
New Hampshire			86.6	23.1	35.9	27.7	1.9		1.0	176.2
New Jersey			3.4			5.0	150.8			159.2
New Mexico	191.6	5.1	638.3			0.7	43.2		0.8	879.6
New York					217.5		407.9	0.7	1.5	627.6
North Carolina	66.3	598.0	85.8	17.8	33.0	93.4	109.4		1.4	1,005.1
North Dakota	1,322.2	6.5	300.3			0.7	3.0		1.4	1,634.2
Ohio	25.0			82.6	204.8	84.7	292.1	295.6	0.1	984.8
Oklahoma	28.3	2.3	279.6	6.3	0.6	45.0	128.9	1.2	5.2	497.3
Oregon	96.6		433.6	25.6		52.9	66.8		0.7	676.2
Pennsylvania					7.8	99.7	698.7	24.8		831.0
Rhode Island					10.5	31.5	7.1			49.1
South Carolina		875.2	94.0		3.0	22.1	38.6	0.2	2.4	1,035.6
South Dakota	195.6		899.4				0.8		0.7	1,096.6
Tennessee	3.3		61.3	50.6	147.1	7.4	21.9		0.5	292.1
Texas	168.8	58.1	2,190.3	362.1	111.2	49.8	196.1	20.8	4.1	3,161.5
Utah	114.9		132.1	9.3		7.8	53.0		0.5	317.5
Vermont			51.3	1.4	17.9		3.5		0.3	74.4
Virginia	18.0	179.0	71.1	108.5	106.0	3.3	134.3		0.7	620.8
Washington	28.1		262.3				177.4		1.4	469.2
West Virginia	106.1	1.7	18.2	4.9	67.1	11.4	54.7	11.4	0.2	275.8
Wisconsin	233.6	140.5	673.8	2.7	9.6		296.5		0.1	1,356.8
Wyoming	190.6	373.1	132.5			1.2	12.9		2.0	712.3
Total	7,015.1	3,727.5	13,810.9	903.0	1,652.3	1,029.2	6,428.2	536.9	53.8	35,156.9

Mileage of Federal-aid roads completed during the fiscal year 1924, by types of construction and by States

States	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land ce-ment con-crete	Brick	Bridges	Total
Alabama		78.1	149.8		17.4	31.2	4.8		0.2	281.6
Arizona	16.0	37.8	85.2			4.0	17.8		0.4	161.1
Arkansas			81.1	4.5	8.3	10.6	15.9		0.3	120.7
California	71.0		86.6	7.3	14.8	5.1	51.4			236.1
Colorado	12.5		63.5			1.0	42.4		0.5	119.9
Connecticut							17.3			17.3
Delaware							26.6			26.6
Florida					20.6	8.6	21.1	3.8	0.1	54.1
Georgia		152.7	100.3	4.5	20.8	9.1	25.5		0.6	313.4
Idaho	2.3		78.9			6.8	12.8		0.1	100.7
Illinois	0.2						168.2		0.9	169.4
Indiana	0.5		12.4				70.4		0.3	83.6
Iowa	269.0		108.2				121.1			498.3
Kansas	37.5	16.8	20.1		8.7		95.7	18.1		197.0
Kentucky	89.0		2.9		41.1		16.8		0.1	149.8
Louisiana			49.3			1.9				51.2
Maine			48.0		12.1		16.8			77.0
Maryland	1.0		5.0			6.5	48.2			60.6
Massachusetts					42.1		22.2		0.3	64.5
Michigan			40.7	8.9		9.3	92.5			151.5
Minnesota	81.2		291.2				6.9		0.2	379.6
Mississippi		14.4	93.5	11.1		3.4	19.0	2.8		144.3
Missouri	104.5		236.6	[1]−28.7	18.0		25.6		0.8	357.0
Montana	25.6		33.5				4.8		0.1	63.9
Nebraska	144.2	100.9	57.1			6.7	24.4	4.4		337.8
Nevada	13.5		24.7	[1] −3.5	15.6		1.2		0.1	51.7
New Hampshire			8.3	5.2	14.5	3.7	1.9		0.8	34.5
New Jersey							37.8			37.8
New Mexico	42.6		129.0			0.7	6.8			179.0
New York					119.2		169.6	0.7	1.4	291.0
North Carolina	3.1	4.5		14.3	[1] −5.0	24.4	68.8		0.1	110.2
North Dakota	497.9	1.5	167.8			[1] −0.4	1.1		0.3	668.2
Ohio	13.5			5.6	33.7	26.6	69.0	119.4		267.7
Oklahoma	0.9	0.3	82.6	6.3		18.2	15.0		0.7	123.8
Oregon			110.7			12.3	9.0		0.4	132.4
Pennsylvania					0.3	14.5	158.1	1.1		174.0
Rhode Island					1.8	3.9	4.8			10.5
South Carolina		292.6	21.5			2.8	3.7		[1] −0.2	320.6
South Dakota	42.2		374.2				0.8		0.2	417.4
Tennessee	3.3			19.3	62.5					85.2
Texas	32.2		429.9	34.5	61.6	40.9	21.9	19.2	0.7	641.2
Utah	39.1		89.3				11.0		0.5	139.9
Vermont			15.6		5.4				0.2	21.3
Virginia	12.0	48.6		17.1	28.6		57.2		0.3	163.9
Washington	1.6		42.9				4.6		0.4	49.4
West Virginia	10.2		7.1		24.3		10.2			52.0
Wisconsin	24.2	18.9	175.4				47.4			265.8
Wyoming	14.3	121.0	30.9						[1] −0.2	165.9
Total	1,604.8	888.2	3,353.8	106.7	566.6	252.1	1,667.9	169.4	10.8	8620.3

[1] Negative figures caused by revision of records when final vouchers were paid on projects the type of which was changed after ratification of project agreement.

The wisdom of the stage-construction policy which has been followed in the approval of gravel and other low-type surfacing materials for a large percentage of the total improved mileage has been definitely proved by experiments conducted by the Iowa State College. These experiments show that the tractive resistance of well-maintained gravel surfaces is only slightly greater than that of the highest types of paved roads. The cost of vehicular operation over such roads is therefore not greatly in excess of the minimum attainable by paving. The original cost is much lower, and so long as the traffic does not exceed in volume or weight the limits within which these lower types are economically maintainable, the experiments indicate that the investment in them is a good one. Other experiments show that the low-type surfaces make the best possible bases for pavements when the traffic reaches proportions which justify paving.

IMPORTANT BRIDGES BUILT WITH FEDERAL AID

One of the most helpful results of Federal aid to road construction has been the bridging of major streams

which it has encouraged and made possible. Such streams are, in many cases, the boundaries of counties or States, and the necessity of securing joint action of the authorities of the two political divisions, coupled with the inadequacy of funds available, has made the construction of modern structures over wide rivers an almost hopeless problem. Yet it is evident that no continuous road system is possible without bridging these barriers.

Federal aid and the coordinating influence of the Federal Government have been the means of securing practical action in a great many cases of this sort. The careful study of the principal lines of travel leading to the designation of the Federal-aid highway system has developed clearly the need of bridges of this character over certain streams and has brought about agreement as to the locations in which the bridges should be built. This benefit has been experienced by the majority of the States, especially those of the South and the Mississippi Valley.

RAILROAD GRADE CROSSING ELIMINATION

In connection with the designation of the Federal-aid highway system and the approval of projects for construction it has been possible to foresee some of the possibilities of railroad grade-crossing elimination. The development of automobile traffic and the statistics of grade-crossing accidents give the fullest possible justification to any reasonable action which will reduce the hazards to both railway and highway traffic at such points.

Studies of the railroad and highway intersections have already been completed in several States, and so far as possible the various grade crossings have been classified according to the degree of danger existing.

The results so far accomplished in the elimination of grade crossings are very gratifying. The State highway departments and the bureau have been able to secure the elimination of 26 per cent of the grade crossings existing in projects submitted to the bureau for approval. Of the total number of crossings eliminated, 65 per cent were removed by relocation of the road and the remainder by suitable overhead structures or underpasses. In a great many cases the grade crossings which remain in a project are branch-line railroads or industrial roads carrying very few trains and, therefore, not warranting at this time the usual heavy costs of elimination. The disposal of 26 per cent of the grade crossings represents, therefore, the elimination of a much larger percentage of the hazard, because elimination is confined more or less to the most dangerous intersections.

FOREST HIGHWAY IMPROVEMENT

In compliance with the Federal highway act of November 9, 1921, forest highway systems have been selected in Alaska and all except three of the Western States in which there are national forests. Negotiations are still under way in California, Oregon, and New Mexico, and it is hoped that a satisfactory agreement can be reached in the near future with respect to the systems of these States.

The forest highway systems, which have been selected by conference between representatives of the State highway departments, the Bureau of Public Roads, and the Forest Service, are composed of three classes of roads, as follows:

(1) All existing and proposed roads or parts of roads, which are necessary sections or extensions of the Federal-aid system wholly within the national forests.

(2) Other existing and proposed roads or parts of roads, which are extensions of the Federal-aid system and partly within or adjacent to and serving the national forests, and which may be designated as forest roads by the Forester and the Chief of the Bureau of Public Roads.

(3) Other existing or proposed forest roads of primary importance to counties or communities.

Present indications are that the forest highway system when completed will include approximately 775 miles of class 1 road, between 6,000 and 7,000 of class 2 road, and between 4,000 and 5,000 of class 3 road, or in the neighborhood of 12,000 miles of forest highways. All future forest highway appropriations must be expended on this system when finally approved. The selection of the forest highway system has required a large number of detailed field inspections in order to determine the fitness of the various classes of forest highways to form a part of the proposed system.

Up to the close of the fiscal year 1,823 miles of forest roads had been completed, the construction of which represented an expenditure equivalent to $18,228,304.52. This amount does not include the costs of administration, surveys, and plans, but does in-

clude an allowance for the Government-owned material and equipment used in the construction. These are charged at slightly less than the current market rates.

The roads completed during the year amount to 286 miles, their total cost on the basis described above being $4,166,861.79. In addition there were under construction at the end of the year 1,042.5 miles, which it is estimated will cost in excess of $16,000,000. The expenditure on these projects up to the close of the year amounted to $8,308,104.44.

Work on the various projects has progressed satisfactorily, and it is expected that the mileage of completed road will be considerably increased by the completion of a number of projects which are now in the final stages of construction. In many sections the season for forest highway work is short. On this account it is desirable that contracts be let as early as possible in the season, and efforts have been made to do so. In some cases, however, the difficulty of negotiating agreements with local authorities has delayed the work.

Traffic has increased on many of the forest highways to a point where it has become necessary to widen some of the earlier projects. It has also been found desirable to surface many of the projects previously constructed, and present plans provide for surfacing, except on those projects where the natural soil is of such a nature that it will carry the traffic without additional surfacing. A considerable improvement has been made in standards, and the roads being constructed as forest highways compare favorably with the roads constructed as Federal-aid highways. It is our endeavor wherever possible to keep the standard of the forest highways equal to those of adjacent State and Federal-aid highways. In the matter of structures, while every attempt has been made to utilize to the fullest extent the local materials available, permanent structures have been built as far as possible.

The bureau has undertaken the maintenance of all forest highway projects for the first two years after their completion. After this period the local cooperator assumes the responsibility and expense of maintenance. The most critical time for maintenance is the first two years after construction, and it has been found desirable for the bureau to handle the maintenance work on the project during this period. At the end of this time sliding of the banks has usually ceased and the surface has been put in a fairly good condition to withstand traffic.

SURPLUS WAR MATERIALS

The distribution of surplus war materials has dropped in quantity to just about the point of minimum economic operation. The following tabulation shows the class of material being distributed:

Surplus war material shipped during the fiscal year 1924

Item	Number	Value
Motor vehicles	860	$1,693,847.40
Tractors	125	530,208.94
Steel buildings	24	132,700.00
Automobile spare parts	-------	1,568,741.00
Tractor spare parts	-------	654,183.00
Engineer and shop tools	-------	433,900.40
Shop machinery	-------	1,007,186.40
Road machinery	-------	86,048.70
Rail and structural steel	-------	135,792.84
Explosives	-------	3,412,820.43
Miscellaneous road-building material	-------	2,616,104.04
Total	-------	12,271,533.15

Of the total volume of material distributed, valued at $12,271,533.15, a part, valued at $8,978,412.23, was distributed to State highway departments, $748,910.12 in value to United States Government departments, and $2,544,210.80 was the value of the explosives shipped to farmers for land-clearing purposes.

The type of material distributed has changed somewhat. The item of motor vehicles, which was the first and biggest single item of war surplus to be distributed and which, up until this year, constituted over 40 per cent in value of the total distribution, has dropped to a relatively small quantity, and during the past year constituted only about 14 per cent in value of the total distributions.

The high percentage of general miscellaneous material has also been lessened, and the greater part of the material now being shipped, as will be seen from the tabulation, consists of shop machinery, road machinery, automobile spare parts, tractors, tractor parts, engineer and shop tools, and explosives.

The two items of shop machinery and explosives have become increasingly important. The total percentage of shop machinery previous to this year was only 2 per cent of the total material shipped. During the past

year the shop machinery shipped amounted to 8 per cent of the total. The percentage of explosives previous to this year was slightly less than 3 per cent of the total material shipped. During the past year the explosives shipped amounted to 28 per cent in value of the total material shipped.

The quantity of explosives shipped during the ensuing year will be still higher. The sodium picrate and the sodatol distributions have been practically completed. Recently, however, a contract has been let for the mixing and cartridging of another explosive, known as pyrotol, which is now available, and from present indications, it will have a still larger distribution than any explosive previously shipped by the Department of Agriculture. The total amount available under the contract is approximately 60,000,000 pounds, representing a value of about $9,000,000.

The total value of surplus war material distributed up to the end of the fiscal year is $241,067,370.65. The class of material distributed is shown in the accompanying table.

Total value of all surplus war material shipped up to the end of the fiscal year 1924

Item	Number	Value
Motor vehicles	35,395	$96,790,449.40
Tractors	2,441	14,441,277.94
Steel buildings	24	132,700.00
Automobile spare parts		23,452,767.00
Tractor spare parts		1,494,053.00
Engineer and shop tools		3,084,973.40
Shop machinery		6,000,424.40
Road machinery		86,048.70
Rail and structural steel		2,109,295.84
Hospital supplies		2,366,134.00
Explosives		10,090,338.43
Miscellaneous road-building supplies		81,018,908.54
Total		241,067,370.65

The estimated sales value of the above material, at the low prices which the War Department has commonly received for property so sold, would have been somewhere between $20,000,000 and $30,000,000. The net gain to the taxpayers of the United States is something over $210,000,000.

IMPORTANCE OF HIGHWAY RESEARCH

For several years the reports of the bureau have referred to the various researches which have been undertaken in the physical and economic fields. We have regarded these investigations as a duty and have looked upon them as no less important than the work of construction represented by the Federal-aid activities. It has been felt that they were imperatively needed, in fact, to insure the successful administration of the construction work.

A number of investigations of the most fundamental character have been under way for several years. Because of their importance it has been felt that they should be conducted in the most thorough manner possible, and the great amount of detail involved in such a treatment has made it impossible to present definite conclusions. After several years of intensive work we are now reaching the point where the several lines of investigation are beginning to produce definite results, and the practical value of these results is most gratifying.

Realizing that road improvement is justifiable only if it facilitates or reduces the cost of necessary and legitimate highway transportation we have been endeavoring to establish the factual basis for a scientific and businesslike administration of highway improvement. As a result of the investigations of the bureau and of other agencies, a number of which have worked in direct cooperation, facts are now being brought to light which, considered in relation to each other, do indicate the general outlines of a scientific method which will practically eliminate guesswork, waste, and uneconomical practices.

To indicate the practical character of the results of the investigations it may be appropriate to refer to a number of phases of the road problems, the treatment of which rested formerly largely upon individual opinion or belief, which are now dealt with in a scientific manner. In the first place, it is no longer necessary that there shall be any doubt as to the necessity or economy of any particular road improvement. Methods have been devised by which it can be determined with scientific accuracy whether or not the improvement of a road is desirable and the form which the proposed improvement should take. The studies of subgrade soils are showing what practical steps may be taken to secure a satisfactory foundation for the roads and what provision must be made in the design of the surface to overcome the handicap of unstable subgrades. It is now possible to design with practical certainty types of road surface which will satisfactorily serve traffic of several classes of den-

sity and weight and to adopt the type of surface to the traffic with considerable precision. Methods of maintenance are gradually crystallizing which insure the conservation of the investments made; and principles of finance have been evolved, based upon the economic and physical investigations, which seem to assure wise expenditure of the public money and a fair distribution of the expense to the several classes benefited.

PHYSICAL RESEARCHES AND TESTS

The physical investigations may be divided into those which have to do primarily with the obtaining of facts leading to the better design of roads to carry motor vehicles and investigations which throw more light on the reasons for the physical behavior of the various kinds of road materials under the present-day motor traffic.

The impact experiments conducted on a very large number of road slabs for the purpose of determining the load-carrying capacity of these slabs when subjected to impact loads have recently been completed and the results have been published. These results add considerably to our knowledge of the proper design of pavements for withstanding heavy loads. In order to bring this series of tests to a successful completion it was necessary to design and build not only the slabs to be tested and the testing machine but all testing apparatus used in measuring the impact forces and stresses. Such measurements have always been recognized as presenting very great difficulties, but these difficulties were successfully overcome.

During the past year a number of stress measurements have been taken on concrete roads having different thicknesses and cross sections, as well as different amounts of steel reinforcement. Here again it was necessary to develop the entire technique and apparatus used in such measurements, as no suitable apparatus for this purpose was in existence. The procedure finally developed was entirely successful and the apparatus, built in our own instrument shops, has given excellent results, so that our knowledge of the action of traffic loads in producing stresses in concrete pavements has been greatly advanced.

Another investigation which was begun during the past year with the cooperation of the Rubber Association of America and the Society of Automotive Engineers deals primarily with the measurement of the impact delivered to road surfaces by motor vehicles equipped with a wide variety of tires and running at various speeds. Other variables include the weight of the vehicle and the load carried. An incomplete set of investigations of this sort was made several years ago. These investigations were recognized as approximate, but even so they have proved of considerable value; in fact, of so much value that the present investigations were requested by manufacturers of automotive equipment. In the present series of tests a very exact method has been developed for measuring impact. This method consists of the use of an accelerometer, which after repeated trial has been made to give results in a most simple and reliable manner. These results will be of very great value, not only to tire manufacturers but to manufacturers of motor vehicles, to road engineers, and to legislators in dealing with legislation pertaining to highways and the control of motor vehicles.

Still another series of tests that have almost been brought to completion during the past year involves the proper design of so-called skew arches, in which the roadway is not perpendicular to the abutments. Here again all test methods and apparatus had to be designed and constructed. These tests have been carried out successfully, and the results, no doubt, will lead to a change in our present methods of skew-arch design.

One series of tests which has attracted considerable attention was conducted on a circular track, built at Arlington, Va., and surfaced with 62 kinds of concrete. The purpose of the test was to determine what are the safe limits of physical properties of aggregates for use in concrete road construction. This question is of great importance. Depending upon the answer to it rests the decision in many cases as to the use of a local material, admittedly not the best, but obtainable without heavy freight charges, or a better material available at a greater distance from the site of the work. The track was 200 feet in diameter and was subjected to rubber-tired traffic by means of a special truck. After thousands of passages, it was established that rubber-tired traffic alone is not harmful to concrete surfaces, but that when equipped with tire chains considerable wear takes place. The safe limit of softness of rock suitable for concrete road construction was likewise established. Various other facts were brought out which will be of great value when they become a part

of active practice in future concrete road construction.

NONBITUMINOUS ROAD MATERIALS

A series of tests of paving brick was made in cooperation with the American Society for Testing Materials with the idea of determining the effect of variation in the size of the brick upon the rattler loss. Parallel tests for hardness and toughness from both the center and surface were likewise run for the purpose of determining difference in quality between the inside and surface. Four samples of paving brick were examined, two of a light-burned and two of a hard-burned variety. Approximately 260 tests for hardness and toughness were made.

In cooperation with Committee C–1 of the American Society for Testing Materials, a comprehensive series of tests in connection with the proposed compression test for Portland cement was begun. This series of tests involved the making and testing of 1,068 specimens.

A series of tests were run involving the fabrication of approximately 70 concrete specimens with the object of determining the relation between the quality of cement and the quality of the concrete in which it is used. The results of this series indicated that whereas quite high variations in crushing strength were observed at early periods, depending upon the quality of cement used, these variations tended to become much less marked as the concrete aged. This work is being continued during the present fiscal year in cooperation with the California State Highway Commission.

An investigation of the relation between the strength-ratio determination of concrete sands and the crushing strength obtained from concrete in which the sands were used was started and considerable data obtained. It was possible during the year to complete the study of three sands. These sands have been tested in concrete in the form of cylinders for compression tests, beams for cross-bending tests, as well as cylinders and beams for mortar tests.

Several methods were tried with the idea of obtaining a satisfactory scheme for estimating the amount of water required to produce a natural sand mortar of normal consistency. The most practical method so far devised is a method which involves a combination of the surface-area principle with a scheme for determining the water-holding capacity of the sand.

A study of laboratory tests for determining quality of rock as concrete aggregate was continued. These studies included an attempt to determine the abrasion loss of crushed-stone samples in such a way as to make the results comparable with the standard test. Seven samples were tested in the laboratory and one sample was submitted to 10 cooperative laboratories for check tests.

The bureau cooperated with the American Society for Testing Materials, the Bureau of Standards, and other agencies, with the idea of developing a universal standard screen scale for testing sieves. Substantial progress has been made along this line and it is hoped that such standardization will shortly result in the use of a single screen scale by all testing laboratories.

Several tests of slag cement were made with a view to determining some method for accelerating the setting and increasing the strength of this cement.

Several sets of tests were made as part of a program in connection with the protective treatment of concrete against alkali action.

Numerous tests to determine the effect of moisture in causing the bulking of sands have been run. In addition, a series of 96 cylinders were fabricated and tested to show the effect of bulking on the strength and yield of concrete. The results of these tests were published in Public Roads.

A method for determining the dye adsorption of soils has been developed and a public patent has been obtained.

BITUMINOUS ROAD MATERIALS

The bituminous investigations upon which most effort has been expended and which have attracted most attention have been those undertaken to evolve tests of bituminous paving mixtures, particularly in regard to their behavior under traffic. During the fiscal year ended June 30, 1923, a circular roadway was constructed comprising 27 sections of bituminous concrete in which the hardness of the asphalt and proportions of the different sizes of aggregates were varied. These sections were then subjected to the traffic of a motor truck with the object of developing the waves or corrugations which occasionally occur in bituminous pavements, and determining the relative stability of the various

mixtures. During the summer of 1923 marked differences in the various mixtures were observed and toward the end of the season, when about 50,000 trips of a 3-ton loaded truck had been made, the surface of a few sections became badly displaced, and this phase of the test was concluded.

The first series of experimental pavements has since been removed and plans have been completed for the construction of a second series, comprising 28 sections of sand mixtures in which the grading of sand, percentage of filler dust, and percentage, consistency, and character of asphalt are varied, together with 5 sections of stone and sand mixtures. These pavements will be laid in the summer of 1924 and subjected to traffic in the same manner as the first series for the purpose of comparing their relative displacement.

The essential purpose of this field test is, however, to furnish a means of correlating service behavior with laboratory tests of mixtures, and while testing known mixtures under traffic the bureau has been experimenting with laboratory tests with a view to developing a test or tests which will indicate the probable stability of a mixture upon the road. The testing of such mixtures is a field of research to which much thought and considerable experimental study has been given at various times, but which has as yet brought out few positive and fundamental facts.

Considerable work has been done in developing methods of making specimens and in tests under compression, but results have not been sufficiently extensive and consistent to warrant the drawing of definite conclusions in regard to this phase of the testing of bituminous mixtures. A great deal of additional study of the behavior of mixtures under traffic and laboratory tests will be required to locate and evaluate the factors causing or modifying the tendency of bituminous pavements to wave under traffic.

The work of the bureau in the standardization of bituminous materials and methods of testing has been carried on along much the same lines as in previous years. In cooperation with the technical committees on road materials of the Federal Specifications Board, new specifications for oil, asphalt, and tar products have been compiled and the bureau has also assisted in the work of the liquid fuels and lubricants committee of the board. Work in connection with standardization of methods of testing has been carried on in cooperation with committees of the American Society for Testing Materials, with special reference to the float test and distillation of tar products, the softening point of asphalt, and the asphaltic content of road oils. The bureau has also participated in the work of the materials committee of the Advisory Board on Highway Research of the National Research Council and the committee on tests and investigations of the American Association of State Highway Officials.

Cooperative experimental tests have been carried on with various State highway testing laboratories in connection with the work of the subcommittee on bituminous and chemical testing problems of the committee on tests and investigations of the American Association of State Highway Officials. The progress report of this committee was made at the meeting of the committee on tests and investigations held in New Orleans, December 3 to 6, 1923. The subjects being investigated by this committee are as follows:

(1) Method for the determination of adhesiveness of bituminous materials.

(2) Method for the determination of the percentage of Portland cement in concrete.

(3) Method for testing premolded expansion joints.

(4) Method for the determination of toughness of bituminous mixtures.

(5) Method for the determination of asphaltic content of road oils.

SUBGRADE INVESTIGATIONS

One of the most important lines of investigation which has been developed recently is that dealing with subgrade materials. It is becoming more and more clearly recognized that the kind of subgrade upon which a road is constructed plays a most important part in the durability of the road and governs to a large extent the loads it will carry. Much laboratory work has been done during the past year in the further standardization of laboratory tests for subgrade material, and in addition a great deal of field work has been performed in order that the laboratory tests might be given their proper significance. The investigations point directly to possible ways in which plastic, volume-changing subgrade materials may be improved by the use of admixtures of more stable granular materials. By field observations numerous facts have been determined as to the movement of moisture

in the subgrade, the relation of temperature to moisture content, and as to the possibility of reducing the moisture content. Field studies have been made in Iowa and Minnesota during the spring thaw, and practical field tests on roads have been inaugurated to test the value of the processes for improvement which have been suggested as the result of field and laboratory observations.

COOPERATIVE RESEARCHES

As in the past, cooperative investigations conducted with a number of cooperating agencies proved to be a very important feature in the research work of the bureau. The projects upon which the cooperative agencies are working have to do for the most part with materials and also with design and economics. The investigations upon which the several cooperating agencies are engaged are as follows:

Purdue University: Various investigations on concrete for concrete roads.

University of Texas: Investigations of soils.

Iowa State College: Investigation of tractive resistance of motor vehicles; investigation of bridge impact; determination of loads on culverts; and an investigation of fuel consumption by motor vehicles when operated over several types of road.

University of Maryland: Various studies in connection with concrete.

Kansas State Agricultural College: The study of wind resistance of motor vehicles.

University of Kansas: Study of tire wear.

Ohio State University: Investigations in subgrade materials.

Pennsylvania Highway Department: Investigations in concrete road design and the better control of concrete in the field.

TESTING HIGHWAY MATERIALS

One of the important features of the work of the bureau is the routine laboratory examination of materials used in road construction. During the fiscal year, 1,769 samples of various road materials were subjected to laboratory examination, 1,350 in the physical laboratory and 419 in the chemical laboratory. Most of the samples were of materials used in connection with Federal-aid projects and the remainder were submitted by individuals or corporations to determine their general suitability for road construction. One thousand and thirty-nine samples of nonbituminous materials were classified and examined in the petrographic laboratory, including 372 samples of rock, 274 of gravel, 305 of sand, and the balance of miscellaneous materials.

As outlined in the last annual report, routine supervision in connection with materials control of Federal-aid projects was discontinued by the division of tests and turned over to the various materials engineers. The system of check-testing in certain States, inaugurated last year, has been continued. As a result of this system, several inaccuracies in the technique of testing were discovered and corrected during the year.

A sand-testing outfit for the use of materials engineers was developed and several sets have already been sent out to the districts. It is planned to furnish district engineers with additional sets as needed.

Two laboratory inspection trips have been made in Federal-aid districts 6 and 8, the first during the fall of 1923 and the second in June, 1924. During these inspections all of the laboratories engaged in Federal-aid testing in the 10 States comprising these districts were visited and conferences were had with materials engineers stationed at Montgomery, Ala., and Fort Worth, Tex.

HIGHWAY ECONOMICS

The economic utilization of the motor vehicle as a transportation facility has opened a new era in the development of transportation. The influence on our national life of the passenger car for social and business purposes and the motor truck for the transportation of commodities is difficult to measure. The rapid growth in the ownership of the motor vehicle demonstrates its value in our economic system, extending and increasing the efficiency of farm operation, developing old and establishing new markets, speeding the conversion of raw materials into finished products, and hastening the processes of marketing and distribution.

In 1923 there were 15,092,177 motor vehicles registered in the United States. The growth in motor-vehicle registration has resulted in a steady yearly increase in passenger-car and motor-truck mileage and an increasing use of the highway. The number of motor vehicles in use in 1923 was twelve times the number in 1913. Gross receipts from motor-vehicle registration fees, licenses, permits, etc.,

have nearly doubled each 2-year period from 1913 to 1921, and increased over 50 per cent from 1921 to 1923. Approximately 80 per cent of the gross revenues from motor vehicles in 1923 was applicable to highway work by or under the supervision of State highway departments.

The result of the rapid growth in the ownership of motor vehicles during the past decade has been a constantly increasing demand for highway service.

With the rapid growth of highway transportation the history of the development of rail transportation has been repeated; conflict, misunderstanding, and duplication of service between the old and new facilities have developed. The utilization of the motor truck for the transportation of freight is a development so recent that its proper sphere as a part of our complete transportation system is still to be established. Recent tendencies in its growth have indicated that its proper field of operation is not in the long-distance movement of commodities, but in a service supplementary to rail and water lines and in the movement of goods within the terminal and short-haul zones. Rail and boat lines are testing the practicability of combined service by the utilization of the motor truck for the movement of freight in the short-haul and congested terminal areas. Its success appears to demonstrate an increased use of the motor truck in this particular field.

The economic development of motor-truck transportation in the future will depend largely upon the stability of organization and the careful regulation of the business.

THE PURPOSE OF TRAFFIC SURVEYS

To provide an authentic basis for the solution of many of the problems of highway construction, maintenance, and transportation, and to develop sound policies to govern the highway transportation of freight and passengers, highway-transportation surveys have been undertaken in Connecticut, California, Pennsylvania, Maine, and Cook County, Ill. The California report has been published and reports of the surveys in Connecticut, Pennsylvania, Maine, and Cook County will be issued by January, 1925. Data have been sought to measure the amount and type of highway traffic, to record traffic information that will aid in solving the physical and economic problems of highway development, to determine the relation of highway transportation to other forms of transportation, and to establish fundamental highway traffic principles.

The principal purposes of the data obtained in the several traffic surveys are as follows:

(1) HIGHWAY ADMINISTRATION AND ENGINEERING DATA

(*a*) To determine daily, seasonal, and yearly traffic flow and distribution on State highway systems.

(*b*) To estimate future traffic on State highway systems.

(*c*) To determine the relation of traffic density to the factors responsible for the growth of traffic, such as motor-vehicle registration, production, and population.

(*d*) To classify highways as industrial, high, medium, or low-type traffic routes based on (1) passenger-car and motor-truck density and (2) motor-truck capacities, gross loads, and wheel loads.

(*e*) To determine the density of motor-truck traffic and the gross tonnage per mile of highway.

(*f*) To determine the maximum loading and frequency of critical loads on the highways as an index of pavement width and design requirements, and to establish highway traffic width and design factors for highways contiguous to large centers of population.

(*g*) To determine the relation between highway width, traffic density, and speed.

(*h*) To measure the effect of congestion at intersections and "bottle necks" upon the rate of traffic flow.

(*i*) To estimate the extent to which the improvement of old or the opening of new traffic routes is economically justified.

(*j*) To correlate traffic loads and density of traffic on the highways with highway construction and maintenance costs.

(*k*) To determine the type and volume of traffic on the highway as an index to the allocation of highway construction and maintenance funds.

(*l*) To determine the distribution of motor-truck loads and the amount and frequency of motor-truck overloading.

(*m*) To compare the cost of various types of highway improvements such as relocations, grade reductions, eliminations of grade crossings, (both rail and highway) and elimination of traffic "bottle necks" with the estimated saving in transportation costs resulting from such improvements.

(*n*) To compare the earning value of the State highway system (based on passenger-miles and freight ton-miles) with the present worth of the highway system using replacement value minus depreciation as the basis of computing present worth.

(2) HIGHWAY ECONOMIC DATA

(*a*) To obtain highway transportation information concerning the volume of tonnage shipped by motor truck, marketing methods, and the relation of highway transportation to other types of transportation.

(*b*) To determine the mileage zones of motor-truck haulage and the relation of the type of commodity hauled to such zones.

(*c*) To estimate the net tonnage of freight transported by regular and irregular trucking operators.

(*d*) To determine the situs of ownership of passenger cars and motor trucks operating over the highway systems.

(*e*) To estimate the value of motor-truck net tonnage hauled over the highway systems.

(*f*) To determine the type of origin and destination as well as the origin and destination of net tonnage of commodities transported by motor truck over the highway systems.

(*g*) To obtain information concerning the relation of motor-truck transportation to other methods of transportation, particularly as to competition, rates, operating schedules, and delivery time in the short, middle-distance, and long-haul mileage zones.

(*h*) To obtain data concerning haulage practices of motor-truck operators, the volume of tonnage transported by motor truck between various cities and areas, and additional data of value to governmental agencies chargd with the regulation and control of highway transportation.

(*i*) To estimate passenger-car business and nonbusiness usage of highways.

(*j*) To determine the proportion of farm traffic on the highways.

AN IMPORTANT SURVEY IN THE CHICAGO METROPOLITAN AREA

A survey of highway-truck transportation and marketing in the Chicago metropolitan area is substantially completed. Data have been recorded regarding the organization, functions, operating methods, rates, services, and operating costs of motor-trucking companies, coordination of highway transportation with rail transportation, and the marketing of special commodities.

Motor trucking in the Chicago metropolitan area is largely a short-haul movement with but a small tonnage movement over 40 miles.

The average gross receipts of commercial trucking companies in Chicago show a marked variation in the efficiency of the various companies. Average gross receipts per year per employee range from $2,000 to $13,750 in the case of the most efficient organizations. Companies engaged exclusively in motor trucking and whose business consists of city delivery other than to and from railways, supplemented by haulage of freight over 20 miles, are the most successful companies.

The principal bases of rates for motor transportation of freight in the Chicago territory are (1) cost of the service, (2) weight of the shipment, (3) length of haul.

One striking fact observed in this investigation is the almost complete absence of cost records maintained by motor-trucking companies.

The field work of a study of the influence of highway improvement on rural land values in 16 counties in Iowa has been completed, and the final report is being prepared. The conclusions from this investigation, supported by a series of similar investigations now in progress, will determine the limits of increase in rural land values resulting from the several types of highway improvements and assist in determining the amount which rural land can economically contribute to highway improvements on the basis of increased values per acre resulting from the highway improvement.

IRRIGATION INVESTIGATIONS

The development of an irrigation enterprise consists of two principal engineering phases: (1) The design and construction of the work necessary to divert and distribute the water to the land; and (2) the location and building of farm ditches and structures, preparation of the land for irrigation, and providing equipment for successful operation of an irrigated farm. The first phase, which usually requires a large expenditure of capital secured by organized effort, has occupied the center of the stage in the past and has often been thought of as being the one engineering feature necessary to be dealt with by those responsible for promoting the enterprise, so that its accomplishment has definitely overshadowed the less conspicuous but no less important irrigation

problems connected with the farm which have usually been left for solution by the individual landowner. So little attention, in fact, has been paid to the farmer's part of the work that irrigation development has lacked the balance necessary for the greatest economic progress. Until quite recently the prevailing assumption was that a constructed canal system would attract settlers of sufficient experience, adaptability, and with the capital necessary to complete the development and discharge the project's obligations.

To this widespread neglect of the settler problem may be traced in no small degree the great financial losses to investors and settlers alike that have occurred at various times during the development of the West. Fortunately, however, the agricultural phase of irrigation is becoming more widely recognized, and the division of agricultural engineering of this bureau has taken a prominent part in the efforts being made to correct past mistakes. It can continue to be of material assistance in solving the farmer's irrigation problems. No enterprise can attain success unless the individual water users are successful, for out of the income from their farms must come the revenue necessary to pay for the operation and maintenance of the irrigation works, interest, if any, on the principal indebtedness, and eventual discharge of the principal itself.

The proper utilization of the Nation's water resources commands wide attention from public agencies and others having to do with irrigation. In line with the need for accurate information are the studies made by this bureau on the utilization of water in irrigation, water-holding capacity of soils, capillary movement of soil moisture, and loss of water by evaporation. Experiments on the duty of water and water requirements of crops have been carried on in cooperation with the State experiment stations of Colorado, Nevada, New Mexico, and with the University of California. The results of these experiments, together with similar data collected in previous years, are being embodied in a series of bulletins, the first of which, Irrigation Requirements of the Arable Lands of the Great Basin, has been submitted for publication. Farmers' Bulletin No. 1348, The Corrugation Method of Irrigation, has been published during the past year.

Investigations of the water-holding capacity of soils, begun two years or more ago, designed to ascertain the amount of water soils of a given type would retain in each foot of depth of the root zone after a heavy irrigation, were continued during the past year on typical irrigated and irrigable soils in 12 of the Western States, and it is planned to prepare the results for publication during the ensuing fiscal year. Another important phase of this general subject is the capillary movement of soil moisture, the beneficial effects of which, however, have until recently been generally overrated, for experiments conducted by this bureau have shown that relatively small amounts of water are drawn upward by capillarity where the water table is low. The experiments show, however, that large quantities can be drawn from the surface of a water table within capillary reach of the ground surface, a fact that has an important bearing upon the drainage of such land. While these investigations are still in progress, a report entitled "The Capillary Distribution of Moisture in Soil Columns of Small Cross Section" has been published as Department Bulletin No. 1221. Finally, the loss of water by evaporation before it can be utilized by plants has formed the subject of continued experiments at the Fort Collins hydraulic laboratory, where more than 500 hourly observations have been made during the past fiscal year under variable conditions of wind movement, temperature, and atmospheric changes. The increasing demand for water, with its ever-mounting cost, makes necessary the most economical use, to which end the extensive studies of this bureau on water utilization are directed.

IRRIGATION AND DRAINAGE LAWS

An equally important group of studies in the field of irrigation economics includes irrigation and drainage laws, operation of irrigation enterprises, the reorganization and consolidation of existing irrigation enterprises, the management of irrigation enterprises, sale and settlement of land in irrigation enterprises, cost of farming under irrigation, and cost of water to irrigators. Studies of existing and proposed legislation at the present time deal largely with irrigation and drainage district laws, which are undergoing changes at a greater rate than are laws covering other features of irrigation and drainage. Engineers of the bureau have kept in close touch with pending legislation and have been of material assistance to legislative committees. During the past year Department Bulletin No. 1177, Irrigation District Operation and Finance, was published,

and there was initiated a parallel study of cooperative irrigation companies, the purpose being to determine the conditions under which various types of cooperative organizations have functioned and to which they are adapted. Cooperative ownership and operation of irrigation works is steadily supplanting control from outside, which makes necessary a thorough understanding of the functions and limitations of the several groups of self-governing agencies if mistakes in organization are to be avoided. The assistance given by the bureau in remodeling irrigation enterprises to eliminate waste of water and duplication of overhead expense has been continued and will doubtless be found of further value as these necessary economies are effected.

In the field of irrigation management, which has developed contemporaneously with the settlement and development of the individual irrigated farm, and which has presented for solution some very perplexing problems, the salient feature of water delivery has been extensively studied and a manuscript of a bulletin prepared for publication. In cooperation with the Bureau of Agricultural Economics a number of typical enterprises have been thoroughly canvassed in New Mexico, Texas, and Colorado with a view to determining the cost of farming irrigated land. It is expected that an analysis of the data secured, which will be made during the ensuing fiscal year, will produce important conclusions as to the relation of irrigation costs to other farming costs and the permissible cost of developing an irrigated farm, regarding which there has existed a singular lack of reliable and definite information. Another phase of this problem, viz, the cost of water to irrigators, has been studied in California under 199 organizations and under a large number of individual pumping plants, the field work, including tests of the plants, being nearly completed and the manuscript of a bulletin also nearing completion.

WATER FLOW AND LOSSES

Irrigation and drainage structures, concrete pipe, and the flow of water in various irrigation channels have been topics of experimental and field research for several years, including the past fiscal year, and are producing results which will mean a great saving to those who pay for the construction of an irrigation system; in other words, a saving to the individual water-users. Although many vertical drops have been constructed in irrigation canals, progress has been slow in developing a type of drop that will eliminate, without great expense, the destruction to the channels below caused by increased velocity of the water due to the drop. The work of this bureau has been directed toward the design of a drop that will accomplish this purpose. Investigations of drainage structures have culminated in the preparation of a manuscript of a bulletin in which are set forth the best principles of design with the idea of increasing the efficiency of drainage systems and reducing the cost.

Although field studies of concrete pipe have not been made during the past fiscal year, a manuscript is being prepared for publication in which will be embodied the results of previous tests of the qualities of such pipe and its adaptability to irrigation development. Field tests have been conducted during the past year dealing with the capacity of flume structures of wood, steel, and concrete and of metal pipe lines, designed to effect great financial saving in the building of such structures. These studies continue the previous work of the division of agricultural engineering on flow of water in various channels which has attracted wide attention.

A bulletin on flow in metal pipes is in course of preparation, and with further experimental laboratory work it is expected to prepare a bulletin on the capacity of flumes, including the losses of energy at the inlets and outlets under varying conditions.

Seepage losses in channels and percolation through earth dams have formed the subjects of several cooperative studies. The increasing need of economy in the utilization of water resources emphasized above is making imperative a reduction in the margin between gross and net duty of water, a reduction intimately connected with the prevention of transmission losses. Seepage measurements on typical canals in California have been continued in cooperation with the State department of public works, and similar investigations in the Lower Rio Grande Valley have been made in cooperation with the Board of Water Engineers of Texas. The report upon the California work, which is nearing completion and which will be submitted for publication as a

bulletin, will present conclusions as to the causes and extent of seepage losses and the most feasible remedies. Preparation of the report upon the Texas work is in progress. In addition to data on amount, location, and means of prevention of absorption losses in canals, it is hoped that proper loss factors for entire systems may be developed for use in determining allowances for losses in granting water permits. The field observations as to percolation through earth dams, continued during the past fiscal year in cooperation with the Bureau of Reclamation, have been recorded at four dam structures on Federal reclamation projects.

Silt and gravel transported by streams cause serious troubles in canal management in some sections of the West. The silt problem on the Colorado River particularly has attracted a great deal of attention because of the volume of silt carried by that stream and the effect upon canal diversion and maintenance. This problem alone is of sufficient economic importance to justify several years of investigation by this bureau. In fact, it is not overstating the case to say that the great irrigation systems of the lower Colorado can reach final success only by a proper handling of the silt question. Plans are now under way to complete the compilation of the results of these studies in order to make them available for publication. During the past year, in cooperation with the Texas Board of Water Engineers, similar studies have been started on certain streams and reservoirs in southwestern Texas, and the work is well under way, its chief value being to determine the life and consequent feasibility of reservoirs for irrigation and flood control. On certain other streams high canal maintenance costs are caused by inundations of gravel carried by the streams during flood periods and lodged against structures and along the upper reaches of the canal systems. Under the supervision of this bureau dams have been built on several Utah streams above canal intakes to catch this gravel, and periodical surveys are in progress to determine the amount of the material so withheld. This work to date has been very gratifying in increasing the effective use of these streams, and it is felt that the experiments will result in provision of means of utilizing the flow of mountain streams now partially or wholly wasted.

THE DRAINAGE OF IRRIGATED LANDS

In many irrigation communities the problem of draining the irrigated land sooner or later demands attention. This problem bids fair to become increasingly serious with the increase in area of irrigated land throughout the West, particularly in view of the fact that much additional irrigated land will be located at higher levels than present areas and will undoubtedly contribute to the drainage troubles of the lower-lying lands. The bureau has been active in giving practical advice and assistance in organization, financing, and construction to communities needing drainage in a number of States. The results of an investigation on drainage conditions in Hawaii made during the previous fiscal year, have been embodied in a report. Department Bulletin No. 1207, Drainage District Assessments, has been published during the past year.

Drainage run-off from irrigated land has been systematically measured in Washington, Oregon, Idaho, Utah, and New Mexico, the bureau cooperating in such work with the officers of Yakima County, Wash.; the experiment substation at Prosser, Wash.; the New Mexico Agricultural Experiment Station; and various drainage districts in Utah. These field studies embrace measurements of the discharge from open and closed drains, depth to ground water in observation wells, percentage of alkali in soil and water, crop censuses, and the relation between the quantity of water applied in irrigation and the resulting quantity of drainage water. In the Mesilla Valley of New Mexico, in which construction of open drains has been practically completed, the observations of behavior of the water table will be valuable in determining the practical results of such open drainage systems after the valley is supposed to have been completely drained. Further investigations have been made of the depth and spacing of drains, the swelling of clay, maintenance and operation of drainage systems, durability of cement tile in alkaline soil, and the removal of salts by drainage.

The bureau has continued its studies of pumping both for drainage and for irrigation. The investigation conducted in Arizona during several previous years to determine the value of pumping from wells as a means of draining water-logged lands has been supplemented during the past fiscal

year with additional field work, and a report of the entire investigation is in course of preparation for publication. That such a publication will be of value is indicated by the interest taken in other communities in this means of possible relief from drainage difficulties which at the same time might increase the water supply for other lands. Provision for such pumping may readily be an important feature of the construction plans of many future irrigation enterprises, particularly where hydroelectrical development is practicable in conjunction with storage for irrigation.

In the field of irrigation pumping the bureau has recently issued Farmers' Bulletin No. 1404, Pumping from Wells for Irrigation. In connection with the work on cost of water to irrigators in California, which includes the cost under individual pumping plants, the pumping plants have been tested for efficiency. There is also under way a project for studying the pumping of water from rivers, canals, and other open-water surfaces. This project has been started on the Snake River in Idaho and Oregon on account of the experience already developed there; later it will be extended to parts of Utah, California, and Texas. Of particular interest and enlightenment should be the results of the investigation along the Snake River, which flows in a relatively deep canyon from which water for irrigation must be raised through high vertical lifts, necessitating heavy operation costs to reach the extensive areas of fertile yet barren lands above it. In cooperation with the Nevada Agricultural Experiment Station, determinations of the capacities of nonflowing artesian wells in southern Nevada have been continued. While the tests show a material increase in capacity resulting from pumping, they are not conclusive, but it is hoped that with the use of a deep-well turbine pump the limit of these capacities may be determined.

A thorough test of a large so-called "water mound," of which there are many in Las Vegas Valley, made to prove or disprove the value of such mounds as a source of water supply by means of pumping, showed that the pump discharge, while holding the spring at a constant level as low as it was possible to hold it without exhausting the spring supply, was no more than the normal flow of the spring. Measurements of the flowing wells in the Las Vegas artesian basin, undertaken with a view to determining the permanency of the underground water supply, were continued. While definite conclusions may not yet be drawn, it appears that in certain sections the supply from the upper artesian strata has about reached the limit of economic development.

WATER-MEASURING DEVICES

The hydraulic laboratory at Fort Collins, Colo., in conjunction with the more recently constructed field laboratory at Bellvue, on the Cache La Poudre, near Fort Collins, has continued to be the means of developing much exact information on measurement of water and its practical application to irrigation needs. The most important work during the past year has been in developing the improved Venturi flume, which has been further tried out under actual field conditions in the Arkansas Valley and is proving to be especially suited for streams bearing excessive amounts of sand and silt. Flumes ranging in size from 1 foot to 10 feet, the largest with a capacity of approximately 600 second-feet, are in successful operation. Deposits are found on the floor of the small-sized structures where very small heads are used, but tests show the error to be only 1 to 2 per cent from the calculated flow; the large-sized flumes have shown no deposit.

A number of other measuring devices and water-recording instruments have been tested at the laboratory. Further work in the design and invention of apparatus has resulted in improvements on the new type of current meter originated by an engineer of this bureau, as well as in the designing of special apparatus for measuring the carrying capacity of pipes, evaporation from ground and water surfaces, and the moisture transpiration of plants.

At the request of the Secretary of the Interior, special investigations were completed during the past year on two projects proposed for construction by the Bureau of Reclamation—the tricounty irrigation project of central Nebraska and the Baker project of Oregon. The study of the tricounty project was initiated during the preceding fiscal year, but was largely carried on and was completed during the year just ended. A distinctive feature of this project is that it lies on the border line between the humid and semiarid portions of the

United States and embraces an area of land already largely cultivated but on which the decreasing yields under dry-farming conditions have been approaching a critical stage. The report deals with certain agricultural engineering phases, chiefly the average monthly deficiency of rainfall during the growing season, the water-holding capacity and probable productivity of the soils, methods of crop rotation possible with irrigation, approximate amount of water needed to supplement the rainfall in order to insure profitable crop production, approximate increase in crop production made possible by subsoil storage, economic advantages of using only direct-flow waters or of providing storage facilities, and the essential features of remunerative irrigation farming.

The proposed Baker project was studied in conjunction with the Bureau of Soils and the Bureau of Agricultural Economics and was the subject of a combined report of the three bureaus. This report went carefully into the phases of agricultural engineering and irrigation economics, a thorough knowledge of which is now coming to be recognized as being vital in planning a successful irrigation enterprise. It dealt in detail with the features of soil quality and adaptability for irrigation, including the presence of alkali, topographic features and their effect upon costs of canal construction and preparation of the land for irrigation; methods of preparation of the land; necessity for drainage measures; equipment required by the settler for recommended types of farming; amount of capital needed by the settler; and probable farming profits.

As in previous years, the bureau has been frequently called upon for advice and assistance in irrigation matters; in fact, it is estimated that during the past year fully 20 per cent of the aggregate time of our engineers has been occupied with such work. While the published bulletins of the department and of cooperating agencies are the means of widely disseminating the results of special studies, such publications necessarily embody only the salient features of a subject and may often be advantageously supplemented in particular cases by the personal aid rendered by irrigation specialists. It is felt, therefore, that the time devoted to such work, so long as it does not interfere materially with research, is time well spent in aid of a better agricultural development.

DRAINAGE INVESTIGATIONS

During the past four years, drainage undertakings by the owners of the lands to be drained have included comparatively few new reclamation projects. New enterprises have been established for increasing the productiveness of lands already largely under cultivation, but much of the drainage undertaken since 1920 has been by districts that had previously completed their original reclamation plans. Owing partly to lack of adequate data upon which to base the design of reclamation works, and partly to the limits of cost set by the landowners, considerable portions of many of the districts were not provided with adequate drainage outlets. Such districts now are enlarging and extending old ditches and constructing supplementary new ditches, sometimes even rearranging the main lines of drainage. Other districts are installing new pumping plants to secure greater capacity or to effect savings in the cost of operation.

The work of the division of agricultural engineering, during the fiscal year 1924, has been limited to research investigations even more than in preceding years, in accordance with the policy of having the State agricultural colleges do as large a part as practicable of the extension work. This permits more satisfactory progress to be made in the investigational activities, and the collection of a larger amount of information for use by the extension workers and others. The fullest cooperation possible is given to the colleges in applying the results obtained to the conditions in their respective States, and in the study of their general drainage problems.

The major subjects of investigation by the division of agricultural engineering are most profitably continued through periods of years, accumulating data that, even though final conclusions can not be attained for many years, are of increasing value as a basis for the design of new drainage works or the reconstruction of older undertakings. The almost innumerable combinations of soil, topography, and ground covering are multiplied by the variations in amount and distribution of rainfall. Determination of the magnitude and frequency of the extreme conditions for any particular area is, of course, a very important step in designing the drainage works. An approach to the maximum occurs very infrequently, and it is always possible that any past record may be ex-

ceeded in the future. However, measurement and study of even moderately severe conditions are very helpful, when more exceptional data are lacking, for estimating the worst conditions for which the works should be designed.

RUN-OFF INVESTIGATIONS

The run-off investigations have been continued along the same general lines as in previous years, the continuity of the records at certain stations being not the least important part of the results secured. Further measurements have been made of run-off rates from five areas in the Little River drainage district in southeastern Missouri, ranging in size from 150 to 75,000 acres. None of the precipitations of high intensity, as shown by the rain gauges established at 10 points, covered the district generally, so only small rates of flow were secured from the largest basin and from the flatland area. However, high discharges measured from the smallest area of rough topography confirm the conclusions of the preceding year that drains for such areas, including highway culverts and sometimes storm sewers, should have greater capacities than generally have been considered necessary. The measurements from the hilly areas of 6,000 to 22,000 acres supplement those previously secured and add materially to the available data for designing adequate and economical drainageways where the run-off from rolling land is to be carried across level drained land. Along Illinois, Mississippi, and Missouri Rivers are many drainage districts for which these run-off data are desired by persons in charge of rectifying mistakes that were made in the design of such floodways.

Measurements of run-off and determinations of resistance coefficients in the formulas for computing channel capacities have been begun during the year in Bolivar County, Miss., and in Champaign County, Ill. As in the Little River drainage district in Missouri, rain gauges over the drainage basins and automatic water-stage registers in the drainage outlet channels furnish the data for comparing amount and distribution of run-off with amount and distribution of precipitation. Current meter measurements of the flow at the various stages and simultaneous determinations of the water slope serve to interpret the water-stage records in terms of discharge and to determine the hydraulic coefficients. The run-off is being measured from eight drainage areas in each of the counties. Those in Bolivar County are of flat topography, typical of much undrained or partly drained land along Mississippi River in Mississippi and Arkansas. The areas in Champaign County are of slightly rolling topography, practically cleared of timber, and some are completely underdrained with tile. Of the 16 channel sections that are being studied for capacity and resistance to flow, 12 are dredged ditches and 4 are natural river channels. On some of the ditches in Champaign County the resistance coefficients will be determined while the waterways are considerably choked with vegetal growth and again after being cleared of that growth, which will afford a comparison bearing upon the value of keeping drainage ditches in good condition. The investigations in these two counties have not been in progress long enough to secure definite results, but the data to be secured will be a valuable addition to those now available.

Preparations were made for gaugings of flood discharge in the St. Francis floodway in northeast Arkansas. That waterway, made by building two lines of levees about 1,200 feet apart between which the flood water will flow over the natural ground surface, offers an excellent opportunity for determining coefficients of resistance to flow through woodland from which only the merchantable timber has been removed. Such floodways of large capacity are practicable in many drainage districts in the lower Mississippi Valley, but the existing data for computing the capacities, and consequently the proper sizes, are extremely meager. The determinations will be of much value also in planning the location and height of levees along the larger rivers, where, as in many locations, it is impracticable to confine the floods to the low-water channel. During the year past there was no depth of flood sufficient for making practical measurements in this floodway, but measurements will be made in the coming year if normal floods occur.

Run-off records for the drainage basin of Luxapallila River in Fayette and Lamar Counties, Ala., have been secured in continuation of those obtained during 1923.

Data were collected as to the cost of operating drainage pumping plants along the Illinois River and the Mississippi River between Muscatine, Iowa, and the mouth of the Illinois. A number of the districts have within

recent years replaced their steam-power plants with electric motors, and others are contemplating a similar change or the installation of internal-combustion engines of the Diesel or semi-Diesel types. There has been a great increase since 1917 in nearly every item entering into the cost of pumping, particularly fuel and labor. The increase in cost of electric power has been very much less, no doubt because of public regulation of rates. While only partial data were obtainable concerning most districts, analysis of the information secured should indicate in some measure the comparative economy of the different kinds of power. There has been little experience so far with the Diesel types for drainage pumping, but the low cost of fuel per horsepower output seems to promise economical operation in this field.

DISCHARGING CAPACITY OF CULVERTS

The experimental studies of 1923 on capacities and forms of culverts, at Iowa City, Iowa, in cooperation with the State University of Iowa, were continued through the fiscal year 1924. The experiments this year were made on concrete box culverts flowing full; that is, with the ends of the culvert opening submerged. This will be the critical condition ordinarily, where the top of the outlet opening is not above the high water in the channel leading from the structure. Nearly 1,100 tests were made on culverts of 24, 30, and 36 feet length, with openings 2 feet square and 3 feet square and some with width increasing through part or all of the length.

It was found that merely rounding the edges of the entrance opening increased the discharge of the culverts from 7 to 10 per cent over the discharge with square edges. Culverts having the rounded edges and widened through the downstream third of their length to twice the width at entrance had capacities 56 to 59 per cent greater than those of equal entrance opening having square edges and a uniform size throughout. The discharge through a culvert 2 feet square at entrance with rounded edges, gradually increased to 4 feet wide by 2 feet high at outlet, was 86 per cent greater than that of the straight culvert 2 feet square with sharp edges. This is equal to or slightly greater than the computed capacity of a culvert 2 feet by 3 feet with rounded edges.

Comparison of the capacities found for the box culverts 30 feet long with those for the pipe culverts of the same length under experiment during the preceding year shows that the 24-inch square culvert, which has about 27 per cent greater area of opening, with rounded entrance, will discharge about 20 per cent more water than a 24-inch vitrified clay pipe laid with bell end upstream, when flowing full; about 30 per cent more than a 24-inch concrete pipe, with the beveled inner edge upstream; and about 70 per cent more than a 24-inch corrugated metal pipe culvert. The computed average velocities were practically equal for the concrete pipe and concrete box culverts. The 27-inch vitrified clay pipe culvert had practically the same cross-sectional area and same capacity as the 24-inch box culvert with rounded edges at entrance, for the 30-foot length, while the 42-inch clay pipe had about 7 per cent greater area and an equally greater capacity than the 36-inch concrete box culvert with rounded entrance.

EFFECT OF ALKALI ON CONCRETE TILE

The experimental studies of concrete drain tile in Minnesota, being conducted in cooperation with the University of Minnesota and the State Department of Drainage and Waters, have been broadened and extended. The manufacture of test cylinders in the laboratory at St. Paul has been continued, with the tests of these and of older specimens after storage in alkaline solutions of various strengths. In all, some 10,000 cylinders have been made for studying the progressive deterioration of the concrete, especially in solutions of magnesium and sodium sulphates, which are the particularly harmful salts that are found in some of the Minnesota soils. A loss of 50 per cent in compressive strength was found for the cylinders of 1:3 mix stored in magnesium sulphate solution of 1 to 4 per cent for 17 weeks or more, as compared with like cylinders stored in distilled water.

Tests have been begun on cylinders cured in a steam chamber, in water vapor at or near a temperature of 212° F. The tests so far, including year-old specimens of 6 series, indicate that this method of curing greatly increases the resistance to attack. Only the slightest signs of deterioration have been evident in specimens stored in the alkaline solutions for 90 weeks. Long-time tests will be needed to determine the actual value of this steam curing, which is very different from the ordinary steam curing in com-

mercial tile plants, where a temperature of more than 100° F. in the curing rooms is not often obtained.

Five sets of experimental drain tile, 1,500 pieces in all, have been installed during the year for observation and test under field conditions. These installations were made in a neutral mineral soil on the university farm at St. Paul; in a sulphate soil in Lyon County, Minn.; in a raw peat soil in Anoka County, Minn.; in an alkali soil containing sulphates and chlorides in Cass County, N. Dak.; and in Medicine Lake in Pennington County, S. Dak., where the water contains about 4 per cent of sulphates, very largely of magnesium and sodium. Some 2,000 of the test cylinders, also, were placed in the same lake.

A reconnaissance has been made of the lands subject to overflow by Mississippi River between St. Paul, Minn., and Rock Island, Ill., to investigate the practicability of reclaiming these lands for agriculture. Of some 340,000 acres subject to inundation at maximum flood stage, outside of low-water channels, it appears that the protection and drainage of probably 12 districts, reclaiming approximately 85,000 acres, could be accomplished at average costs of from $50 to $75 per acre for the various districts. Considerable farm drainage and clearing of woodland not included in these cost figures would be required before all the land would be ready for cultivation. Buildings and other private and community improvements would add further to the cost of the developed farms. Pumping of the drainage water would be necessary during the greater part of each year. Determination of the fertility of the soil was not attempted, and it is quite possible that in one or more of the districts suggested the land when reclaimed would not be worth the cost.

STUDIES OF FARM-LAND EROSION

An experimental study of erosion of farm land has been begun in North Carolina, in cooperation with the agricultural experiment station. The first experiments will go into the rate of erosion and its relation to the amount and intensity of rainfall, the ground slope, the soil type, and the kind of crop on the land. Thus far, six plots of various lengths up to 200 feet, having a fairly uniform slope of approximately 9 feet in 100, have been inclosed by tight fences, so that the eroded material is caught and weighed. In two months the erosion from a Cecil sandy-loam soil cultivated in cotton has been 25 tons per acre, or about 0.2 inch depth. So short a period does not give dependable results, and the experiment will be continued. It will be extended to include field and laboratory studies of terracing for the prevention of erosion. Terracing has been practiced for many years in the South Atlantic States, but the value of this method of treating hillside fields is not limited to that region. The use of terraces is being urged by agricultural colleges for lands in the Ohio and Missouri Valleys, and will be beneficial elsewhere. This subject has received some little attention in previous years, but knowledge of the proper design of terrace systems under various conditions of climate, soil, topography, and culture is far from complete.

The studies in North Carolina of the effect of varying the depth of tile drains upon the depth of ground water in a Norfolk fine sandy-loam soil, and of the effectiveness of open field ditches in the drainage of muck soil, have been continued but not to quantitative conclusions. The year's observations emphasize, however, that the deeper drains maintain a lower general elevation of the plane of saturation, and that it is difficult to maintain open ditches at the desired depth in the muck.

DRAINAGE AND IRRIGATION OF SUGARCANE AND CITRUS FRUIT IN THE GULF STATES

The varying rainfall in the Gulf-coast region provides in some years an excess of moisture for the best growth of sugarcane and in other years an insufficiency. The study of irrigation for cane, undertaken in the preceding year in cooperation with a sugar planter in southern Louisiana, has been broadened to include a study of the practicability of drainage for that crop. The precipitation was above normal during the growing season of the crop harvested in the fall of 1923, and the several acres of better drained land yielded more cane per acre than the plots with average drainage selected as comparable in other respects. The results concerning irrigation were inconclusive, owing to the large rainfall, but lack of rainfall during the summer of 1924 seems to indicate that irrigation rather than drainage will show results in the crop to be harvested this fall. Both for drainage and for irrigation only the average results over a period of years will show what increases in yield may be obtained and whether profits may be

expected from the installation of drainage or irrigation improvements.

On the east coast of Florida, in places, protracted periods of drought have been attended or immediately followed by the death of many trees in citrus orchards. In one grove some 200 trees were removed this year. The loss of a tree entails not only the cost of removal and replacement but also the loss of crop for five or six years until the young tree is yielding profitably. An investigation has been begun to determine whether a deficiency in the soil-moisture content really is the cause of the losses, and whether irrigation will remedy or prevent the injury. In some of the affected areas frequent determinations of soil-moisture content are being made, and experimental irrigation in connection with fertilization of some of the trees that had begun to show the characteristic wilting is being carried on at the same time. The owners of the orchards where the experiments have been started are cooperating in the work. The investigation will be continued in cooperation with the citrus growers and will include studies of the movement of the irrigation water in the soil, the quantity to be applied, and the most economical and effective methods to be used.

In cooperation with the extension department of the agricultural colleges in a few States, advice and assistance have been given in farm drainage, terracing, and the initiation of community drainage enterprises as in previous years. Besides the aid to individual farmers whose drainage and terracing improvements will be effective demonstrations in their respective localities the bureau planned and supervised the installation of a tile drainage system for about 20 acres of a 50-acre pecan orchard in Lee County, Ga., upon which the Bureau of Plant Industry is conducting experiments.

DISTRIBUTION OF SURPLUS WAR EXPLOSIVES

The purposes of the distribution of surplus war explosives to farmers, which has been carried on for three years, are three in number: (1) To make an economical use of this material, which otherwise would be destroyed as waste; (2) to enable farmers who need explosives to save money in buying a suitable material; and (3) to use such explosives as a means of interesting farmers in improving their lands and to educate them in the best means and methods of doing such work.

At the beginning of the fiscal year the bureau had on hand 150,000 pounds of cartridged picric acid for agricultural work. This was distributed during July and August. The available supply of surplus war explosives then consisted of some 8,000,000 pounds of trinitrotoluol (TNT.) and 10,000,000 pounds of sodium nitrate. After extensive investigation a formula for an explosive made of these two materials was developed, and this explosive, "sodatol," was used by thousands of farmers throughout the country and gave universal satisfaction.

Bids for preparing the sodatol were received from five manufacturers of explosives in July, 1923, and the contract was let to the lowest bidder. The price agreed upon ranged from 4.07 to 5.20 cents per pound, and shipments were made from Repauno, N. J., Barksdale, Wis., Ashburn, Mo., Louviers, Colo., or from Dupont, Wash., in order to secure the lowest delivered price to the farmers.

More than 14,000,000 pounds of sodatol had been distributed in nine months when shipment of the last of this material was made, in June, 1924. The distribution to farmers was handled by cooperation with some agency in each State, usually the agricultural extension service of the State agricultural college. These agencies secured the orders from the individual farmers, pooled them into carload lots, looked after the details of the distribution when the shipments reached destination, and carried on the educational work connected with the use of the explosive. The success of the distribution is largely due to the enthusiastic cooperation given by the State agencies. The following table gives the distribution by States:

	Pounds
Alabama	76,000
Arkansas	1,000
California	50,000
Connecticut	38,900
Florida	21,000
Georgia	36,000
Hawaii	1,000
Idaho	531,200
Iowa	225,250
Kansas	1,700
Kentucky	38,150
Louisiana	32,600
Maryland	1,000
Michigan	1,533,000
Minnesota	1,773,500
Mississippi	71,100
Missouri	101,000
Montana	135,200
Nebraska	47,900
New Jersey	600
New Mexico	500

New York	26,000
North Carolina	657,650
Ohio	17,000
Oregon	980,400
Pennsylvania	35,500
South Carolina	180,700
South Dakota	73,000
Tennessee	72,800
Texas	40,050
Washington	2,269,250
Wisconsin	5,044,200
Total	14,113,150

No charge was made for the explosive materials, but the farmers paid the cost of preparation, the overhead expenses of the distribution, and the freight charges. As nearly as can be determined, the average cost of sodatol to the farmer at his railroad station was 6½ cents per pound, while the average price of an equivalent amount of commercial explosive in carload lots was about 17 cents. Thus the saving to the farmers on the total amount distributed can be conservatively estimated as not less than $1,500,000. This amount would be greatly increased if comparison had been made with the retail selling price of the commercial explosives. Reports indicate that at least 50,000 farmers used this explosive and so were benefited by the distribution.

COMMENTS ON THE VALUE OF SODATOL

A large part of the sodatol was distributed in States having cut-over lands, where it was used, not as an inducement to get more settlers on the land nor to open up new areas for settlement, but by farmers who are struggling to get enough land under cultivation to make each farm self-sustaining. However, a greater amount was used in making lands already in cultivation produce more crops at a less cost, by removing stumps and bowlders and squaring up irregular fields. The use of sodatol was by no means confined to the States generally considered as comprising the cut-over areas; in fact, great interest was shown in many States, such as Iowa, which are ordinarily thought to have completed the clearing of the land. A recent survey shows that in one of the best agricultural counties in the lower peninsula of Michigan 35 per cent of the total land now being cultivated is stump land.

The value of this use of surplus war explosive is attested by all the reports from the State distributing agencies. The report from Wisconsin states, in part:

> Individual efficiency * * * is the first and shortest way out of the present farm difficulty, and the very large increase in the use of explosives by southern Wisconsin farmers is an indication that we have been able to sell this idea to them. This material [sodatol] has not been used largely to increase acreage and production, but rather to remove stumps and stones which have been obstructing cultivation, causing costly delays and extensive repairs to machinery and equipment, loss of labor and increased general cost of production, and consequent lowering of profits. Thousands of farms in southern Wisconsin still need land clearing and land reclamation in order to make them efficient farm units.

The Michigan report says, in part:

> During the period of distribution of surplus war explosives, aproximately 200,000 acres have been cleared * * *. The total amount of surplus war explosives distributed [in Michigan] is 2,718,300 pounds, which would indicate that there was used an average of 13.6 pounds per acre. As our average saving is 14 cents per pound, the average saving per acre cleared would be only $1.90, but this is hardly fair. Fully 50 per cent of the 200,000 acres used practically no explosive. The other 50 per cent used at least 80 per cent of all the explosives, which would indicate a saving of more than $3 per acre. * * * We feel free to say that 60,000 acres would never have been cleared had it not been for surplus war explosives.

Minnesota reports that about 62,800 acres of land were cleared of stumps and bowlders with sodatol and that the saving over the cost of commercial explosives was $6.13 per acre, or a total of $385,000.

Due in part, at least, to the interest aroused in farm development by this work, a number of investigational projects have been undertaken by various States. These investigations in general seek to determine the best methods of getting rid of stumps and bowlders and the value of the benefits obtained by such removal.

The distribution of sodatol was completed in June, 1924, and plans have been perfected to begin the distribution in a similar manner of another explosive called "pyrotol," the formula for which was developed in the division of agricultural engineering. This explosive will be composed largely of ground smokeless powder and sodium nitrate, and probably will be the last surplus war explosive to be distributed.

FARM MECHANICAL PROBLEMS

The importance of power in agriculture has long been recognized, but it becomes much more apparent in the light of data collected in a survey of the use of power on farms in the United States made during the past

year by this bureau. More primary power is used in agriculture at the present time than in any other industry except transportation. Power and labor represent over 60 per cent of the total cost of carrying on the farming operations. Nearly 16,000,000,000 horsepower-hours are used annually on farms in the United States, and the cost exceeds $3,000,000,000 each year. It is by the use of this power that the American farmer has been able to multiply his production by at least 3 in the past 75 years. The average amount of power used on farms in the United States at present is about 2,500 horsepower-hours per farm, about 1,500 horsepower-hours per farm worker, and about 32 horsepower-hours per acre of improved land. It requires about 32 horsepower-hours to produce, harvest, and haul to market 1 acre of crops on the average.

Electricity has been substituted for other forms of power in many industries; and if it could be supplied to farmers at a cost which would admit of profitable returns, would greatly increase the productiveness of agricultural workers. The cost of long-distance transmission, distribution, and transformation, the small number of consumers per mile of transmission, and the small intermittent loads of the individual consumers impose conditions under which the central power companies could not now secure a profitable return on their investment. The only way in which the cost of central-station energy can be so lowered as to render the general use of electricity in agriculture profitable is to increase its profitable agricultural uses.

With this in view, the committee on the relation of electricity to agriculture, composed of representatives of the American Farm Bureau Federation, the American Society of Agricultural Engineers, the National Electric Light Association, and the U. S. Departments of Agriculture, Commerce, and Interior, has been formed. The purpose of the committee is to formulate a program to serve as a guide in planning and conducting investigations as to the profitable uses of electricity in agriculture. In order that farm problems might be better understood, the committee requested the Department of Agriculture to make a general survey of the use of power on United States farms. This survey, the report of which is practically completed, was made during the past year and consists largely of a compilation of all reliable information now available. The report shows the various present uses of power on the farms, the amount of different kinds used, the power required for some of the major farm operations, and the geographical and seasonal distribution of power requirements, and contains much other information of a statistical nature. It will be of value to all those interested in the development of power equipment and the production of farm machinery, as a basis for investigations to determine the fundamental facts regarding the actual power required in farm operations and for the design of farm equipment.

The increasing cost of coal has brought into the market a large number of oil burners for house heating. Because of the many requests for information and advice concerning them, an investigation was undertaken in cooperation with the Bureau of Home Economics for the purpose of obtaining first-hand information regarding the efficiency and operating characteristics of the several types offered the public. As the work was undertaken late in the year and it was necessary to install considerable laboratory equipment, the investigation has not progressed to the point where definite statements can be made. The data so far obtained indicate that information obtained will be of value to manufacturers who wish to increase the efficiency of the burners and to users in operating the equipment after installation.

DEVELOPMENT OF COTTON-DUSTING MACHINES

The work of developing and testing cotton-dusting machines and equipment for spreading insecticides to poison the cotton boll weevil has been continued through the year in cooperation with the Bureau of Entomology, with headquarters at the bureau's laboratory at Tallulah, La. Apparatus for spreading calcium arsenate from airplanes and balloons has been given most attention during the year. Fairly satisfactory progress has been made, though a great deal of additional experimental work probably will be necessary before the many possible variations in the equipment have been tested and the anticipated degree of perfection is achieved. New or improved types of dusting machines continue to be submitted by private manufacturers for test, and an engine-driven traction duster has been developed.

The investigation in cooperation with the Bureau of Plant Industry looking toward greater economy and efficiency in the transportation of fruits and vegetables included tests made at Arlington, Va., on two refrigerator cars furnished for the purpose by the Pacific Fruit Express, to determine the effect of body icing on the car insulation. Body icing is the use of ice directly upon the lading, a practice that is used to a limited but increasing extent in some parts of the country, although the melting ice keeps the floor of the car wet while being so used. One of the cars had been used for shipments with body icing, and the floor had been more or less saturated with the water; the other car had not been so used, according to the records, and the floor had been kept dry. The tests consisted of measurement, by direct methods, of the loss of heat through the floors of the cars. Some of the testing apparatus being new in type, considerable experimentation was required to develop satisfactory methods, but sufficient work has been done to show that the practice of body icing results in appreciable damage to the floors of the refrigerator cars.

The refrigerator car of the Bureau of Plant Industry was entirely reconstructed to conform, as regards the internal arrangement, with the recommendations made by the Department of Agriculture and promulgated during the World War by the United States Railroad Administration in its standard refrigerator-car specifications. Further provision was made for readily changing the bulkhead and bunker construction, so that experiments on the effect of various modifications can be made. The work was done at Potomac Yards, entirely at the expense of the Bureau of Plant Industry. This project now has a refrigerator car suitable for either laboratory or road tests, including the actual shipment of perishable products in comparison with other cars.

During the year specifications were prepared for the purchase and installation of new equipment and the rearrangement of some of the present equipment in the cold-storage laboratory of the Bureau of Plant Industry at Arlington Experiment Farm. The new equipment includes two ammonia compressors and one brine tank, already secured to add to the previous equipment, and a new electric switchboard yet to be purchased.

To provide means for studying methods of minimizing damage done by frost, in connection with the study of transportation of citrus fruits, equipment was needed for experimentally freezing the fruit on the tree. For this purpose a sectional freezing chamber of insulated panels was designed and constructed so that one man can place it about and over the tree to be frozen. Low temperatures are obtained by a specially designed air-cooling tank. After tests on apple trees at Arlington Experiment Farm the apparatus was shipped to California and used for freezing citrus trees, and thereby considerable data were obtained concerning the effects on both tree and fruit of different freezing temperatures maintained for various periods of time. In operation, temperatures in the chamber were maintained fairly steadily throughout the night 30° to 35° below those outside, with a variation of only 5° to 7° between the top and bottom temperatures inside.

VENTILATION OF FARM BUILDINGS

The importance of the proper ventilation of farm buildings in which stock and crops are housed is becoming more and more generally recognized. As it has been necessary to provide man with warmth, light, and abundant fresh air in his working quarters, so it has been found necessary to provide farm stock with adequate shelter and to maintain them in good health if maximum production is to be had. Crops must be stored on the farm for greater or less periods of time in the interest of orderly marketing or to complete the processes of production, as in the case of tobacco. In practically every instance it has been found that the question of ventilation is of vital importance. The problem of providing proper ventilation resolves into two major phases, of which one is the determination of the atmospheric conditions that must be maintained within the structure to insure health and productiveness in animals and to prevent spoilage in stored crops. This part of the problem is a subject for the animal nutritionist and other specialists in the animal and crop production. The other phase is an engineering problem and consists of devising the means for obtaining and maintaining the desired atmospheric conditions. The use of mechanical equipment for this purpose by the farmer is prohibited by the cost of installation and operation, so the desired end must be attained through the utilization and control of natural air forces. Efforts to devise

efficient means of doing this have been hampered by the lack of knowledge relating to unknown and uncontrollable factors affecting the ventilation of farm buildings. The investigation to determine the fundamental principles upon which the design and operation of ventilating systems might be based was continued during the current fiscal year.

From observations and tests made under operating conditions in a number of dairy barns, data have been secured which will be of material assistance to engineers and designers of ventilating system as well as to the farmers who must operate them. Farmers' Bulletin No. 1393, Principles of Dairy Barn Ventilation, has been prepared and published during the past year, to acquaint farmers with the necessity for the ventilation of the dairy barns, the principles involved, and the systems in common use. Papers also were prepared and presented before technical societies.

PLANS OF BUILDINGS AND EQUIPMENT

There were prepared in the bureau a number of plans for farm buildings and equipment, many of which were designed for general distribution at the request of or in cooperation with other bureaus of the department. The investigations of specialists in animal husbandry and crop production frequently result in recommendations as to conditions to be obtained within buildings intended for the housing of animals or crops, or as to facilities or equipment embodying or permitting of the adoption of such recommendations, and the best means of conveying to the farmer the information that will assist him in building construction. As the preparation of such plans often involves engineering problems, the cooperation of this bureau is sought in this connection. The bureau now has on hand a large number of designs for buildings and equipment, prints of which are available to those who contemplate building. Descriptive lists of these designs may be had upon request.

There was prepared and issued for the use of college authorities a classified list of the farm-building plans prepared by all the colleges and this bureau. This list enables the authorities to locate and obtain for their own use plans of suitable structures for which they do not themselves have drawings. It also makes it possible for the bureau to refer inquiries from a given State to the agency in that State from which plans designed to meet local conditions may be obtained. When suitable plans are not available, the correspondent is given the best advice and assistance possible. A scheme of cooperation is now being developed which, it is hoped, will make practicable a complete interchange of such plans as are mutually suitable to the conditions prevailing in two or more of the States, thus avoiding duplication of effort and making available to the farmers of the respective States a much larger choice of plans, at a considerably lower cost to the States and to this bureau for the services rendered.

The increased cost of building has led to a considerable interest in pise de terre, or rammed earth, as a building material. This old type of construction was employed for many years in Europe, and to a very limited extent in this country when transportation facilities were lacking. During the World War its use was revived, especially in England, as a means of meeting the high cost of materials and labor. The use of this method of construction, at least in certain types of buildings, apparently has much to recommend it, but there is lacking exact knowledge as to the kinds of soil best suited to the purpose, the durability of such construction, and the most economical methods of handling the materials. Because of the many requests for information concerning this method of building, a memorandum summarizing the available information was prepared for use in replying to such inquiries.

A new bulletin on farmstead water supply was prepared to better supply the information being requested by an increasing number of farmers concerning this subject. It supersedes an older publication relating to the same general subject, but is more profusely illustrated and includes new material pertaining especially to the planning of the water system for the farm, pumping, and the provision of storage facilities.

For the use of the Office of Cooperative Extension Work, there was prepared lantern slide series No. 105, on farm sanitation, consisting of 33 slides with a syllabus based on a bulletin published previously.

STUDIES OF THE USE OF TRACTORS

A study of the problems of tractor farming in California has been started in cooperation with the University of California. The types of farming fol-

lowed in California lend themselves very well to the use of tractors. Few crops of the row type are produced, and as a result tractor power can be used for almost all farm operations. Certain soils and climatic conditions that exist in California, however, have produced numerous mechanical difficulties that ordinarily are not encountered in tractor farming. Much of the soil is of a fine gritty nature, and the long dry spells that are common in the West cause an excessive amount of dust to be formed. As a result of these two conditions, very rapid wear occurs in the tractors, and there is extraordinary difficulty in obtaining traction. It is with a view of collecting information that will help solve these mechanical difficulties that the tractor study has been undertaken.

Two bulletins on tractor farming were issued during the year. One is a study of the use of tractors in the winter-wheat belt, and compares the costs of supplying power with horses and with tractors. Comparisons of cost were computed on 1921, 1922, and 1923 values. The other bulletin discusses the utilization and cost of using tractor-drawn implements. It is based on data obtained in tractor investigations previously made, and is intended to be helpful to those who practice power farming or who contemplate a greater use of mechanical power.

FERTILIZER DISTRIBUTION

The use of high-grade fertilizers is being discussed a great deal at the present time in connection with the disposition of Muscle Shoals, and the Bureau of Soils, the Bureau of Plant Industry, and the Fixed Nitrogen Laboratory have been working for some time on the development of extremely high-percentage fertilizers. If these more concentrated fertilizers prove practical, it will mean the cutting down of the rate of application per acre to as low as one-third and in some cases to one-fifth as much as is now used. There is serious question, however, as to whether the fertilizer distributors now on the market can be successfully operated at these low rates of application. Also, under certain conditions fertilizers now used may cause serious damage when they come in contact with germinating seed and growing plants, and it is possible that such damage will be much greater in case more concentrated fertilizers are used. For these reasons the division of agricultural engineering has been asked to make a study of the mechanical problems of fertilizer distribution, with a view to devising improvements that will handle the small amounts and so distribute the fertilizer as to prevent crop injury. Arrangements are being made to start this work shortly after July 1, 1924.

ENGINEERING PROBLEMS

By collecting and disseminating the information of an engineering nature secured by other investigators it has been possible to render assistance to thousands of farmers and others confronted with structural, mechanical, and other engineering problems to whom other sources of advice and information are not readily available. This service is rendered largely by correspondence and involves a very large portion of the time of the personnel engaged in agricultural engineering work.

PUBLICATIONS, EXHIBITS, AND MOTION PICTURES

The educational extension work has been carried on along the same lines as in previous years. Information in regard to the various subjects within the field of the bureau's activities has been laid before the public by means of publications, motion pictures, exhibits, and lantern slides.

New motion pictures have been made of the highway experiments at the Arlington Experiment Farm, tests of guard rails by the Pennsylvania State highway department, and films which will be developed into two 2-reel pictures were made in connection with the highway inspection tour of the Pan American Highway Commission in June, 1924. In the preparation of these pictures the bureau cooperated with the Office of Motion Pictures.

Besides cooperating with the Office of Exhibits in the preparation of models and exhibit booths for exhibition at eligible State fairs and assisting in the demonstration of department exhibits at such fairs, the bureau has prepared special displays for automobile shows and highway conventions. These special exhibits of the bureau are eagerly sought by the largest of the automobile shows, by the American Road Builders' Association for its annual good-roads show at Chicago, and by other highway associations.

Publication of the magazine Public Roads, which was resumed in March, 1924, is the most important development in this field of the bureau's activities. The new publication is a monthly journal of highway research in which it is proposed to publish reports of all researches and tests of the bureau and its cooperators. The four issues published during the fiscal year have been enthusiastically received by highway engineers in this country and abroad.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1924

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., October 15, 1925.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1925, covering briefly the work done in connection with the construction of Federal aid and national forest roads, and, more completely, those functions of the bureau which are provided for by the act making appropriations for the Department of Agriculture. A more complete report of the Federal aid and national forest road work will be made subsequently as provided in section 19 of the Federal highway act, approved November 9, 1921.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

Hon. WM. M. JARDINE,
Secretary of Agriculture.

FEDERAL-AID HIGHWAYS

By completing 11,328.6 miles of Federal-aid roads during the fiscal year 1925 the cooperating Federal and State governments established a new record. The greatest mileage previously completed in any one fiscal year was the 10,247 miles completed in 1922. The new record exceeds by 30 per cent the mileage completed in the fiscal year 1924, and by more than 50 per cent the aggregate mileage completed during the first five years of work under the Federal-aid plan.

The year's work brings the total of mileage completed since the passage of the first Federal-aid road act in 1916 up to 46,485.5 miles; and in addition to the mileage completed a great deal of work has been done on the 12,462.6 miles which at the close of the year were under construction. The program of work thus far undertaken includes the above mileage completed and under construction and an additional 2,181.6 miles approved for improvement with Federal aid but not yet placed under construction. Including this latter mileage the program of Federal and State cooperation in road building as definitely planned or completed to date involves 61,129.7 miles, of which all but 3,570 miles undertaken prior to the passage of the Federal highway act in 1921 are included in the interstate or Federal-aid highway system designated in accordance with the provisions of that act.

FEDERAL-AID HIGHWAY SYSTEM TWO-THIRDS IMPROVED

The mileage of the Federal-aid highway system is limited by law to

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U. S. Dept of Agriculture
Aug. 1, 1931

200,349 miles, which is 7 per cent of the total mileage of highways in the United States at the time of the passage of the Federal highway act. Up to the present the system as designated includes only 178,797 miles. Of this mileage, as indicated above, approximately 57,560 miles has already been improved or undertaken for improvement with Federal aid. As the States alone, without Federal assistance, have completed or have under construction an additional mileage on the system amounting to over 65,000 miles, it will be seen that approximately two-thirds of this system, designated since 1921, is already completed or under construction. When the system was designated it was hoped that its improvement could be completed within 10 years. At the present rate it is apparent that this hope will be realized and that within five more years, if nothing happens to retard the progress, there will be a continuous interstate highway system connecting every city of 5,000 population or larger, and every section of it improved to a degree consistent with the density and character of the traffic.

The year's mileage completed constitutes a varying percentage of the Federal-aid highway system in the several groups of States. As the designated system is in all States practically the same percentage of the total mileage of highways, and as in all States it includes the most important highways, the ratio of the mileage of Federal-aid roads completed during the year to the mileage of the system in each State or group of States may be taken as the index of the rapidity with which the highways of the section are being improved with Federal aid

Analyzing the year's record in this way it appears, as shown in Table 1, that the most rapid progress toward the completion of the Federal-aid system with Federal participation was made in the West South Central States,[1] where the mileage completed during the year was 8.6 per cent of the total mileage of the system. In these States the progress of the cooperative construction would, if continued at the same rate, without other construction, result in the completion of the Federal-aid system in less than 12 years.

Compared in the same manner with the mileage of the Federal-aid system the year's progress in the cooperative work by other groups of States is indicated by the percentages shown in the third column of Table 1. Ranked in the descending order of percentage improved during the year the several groups are: West South Central, 8.6 per cent; East South Central, 8.2 per cent; Mountain, 7.6 per cent; South Atlantic, 6 per cent; Middle Atlantic, 5.8 per cent; West North Central, 5.5 per cent; East North Central, 5 per cent; Pacific, 4.9 per cent; New England, 4.4 per cent.

Forty-three per cent of the mileage completed during the year was built in the 16 States which comprise the East and West South Central and Mountain groups. These States, almost without exception the largest in the country, include 49 per cent of the total land area of the United States. Somewhat later in commencing the improvement of their roads than the other States, they are now making rapid progress in the building of their main highways with Federal aid. Fortunately their highway traffic is still considerably lighter than in other States and they are able, therefore, to build a greater mileage of satisfactory highways at a given cost than the other States. This is indicated by the fact that while their completed mileage was 43 per cent of the year's total, the total cost of the roads completed was only 35 per cent of the total cost of all roads completed with Federal aid during the year.

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[1] The various groups of States referred to are as follows:

New England States: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island.

Middle Atlantic States: New York, Pennsylvania, New Jersey.

South Atlantic States: Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.

East North Central States: Ohio, Indiana, Michigan, Illinois, Wisconsin.

East South Central States: Kentucky, Tennessee, Alabama, Mississippi.

West North Central States: Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas.

West South Central States: Arkansas, Louisiana, Oklahoma, Texas.

Mountain States: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada.

Pacific States: Washington, Oregon, California.

TABLE 1.—*Federal-aid mileage completed during the fiscal year 1925 compared with the mileage of the Federal-aid highway system by groups of States*

Group of States	Federal-aid roads completed	Federal-aid highway system	Portion of Federal-aid system improved with Federal aid
	Miles	*Miles*	*Per cent*
New England	256.2	5,789	4.4
Middle Atlantic	571.4	9,879	5.8
South Atlantic	1,272.7	21,155	6.0
East North Central	1,293.7	25,740	5.0
West North Central	2,561.3	46,435	5.5
East South Central	1,149.8	14,020	8.2
West South Central	2,096.1	24,282	8.6
Mountain	1,626.2	21,308	7.6
Pacific	501.2	10,189	4.9
Total	11,328.6	178,797	6.3

FEDERAL AID A VITAL FACTOR IN CENTRAL AND MOUNTAIN STATES

The degree to which the States of the several groups are dependent upon Federal participation to enable them to carry on the work of highway improvement is indicated by Table 2 in which the mileage of Federal-aid roads completed during the fiscal year 1925 is compared with the total mileage of highways constructed under the supervision of the State highway departments during the calendar year 1924. Unfortunately the data are not available which permit this comparison to be made on the basis of exactly the same period, but the difference in time is not great enough to be material.

It is apparent from Table 2 that the Federal assistance is a very important factor in the East and West South Central States and the Mountain States where the Federal-aid roads constitute from two-thirds to three-quarters and more of the annual program of construction. In the Middle Atlantic and East North Central States the percentage of roads built without Federal assistance is highest, being more than two-thirds of the annual program in each case, whereas, for the country as a whole the Federal-aid program is practically half of the annual construction program carried on under the State highway departments.

While the Federal aid is thus shown to be in all States a considerable factor, invaluable to some and helpful to others, the fact that in all groups of States from a fifth to two-thirds of

TABLE 2.—*Federal-aid mileage completed in fiscal year 1925 compared with total mileage completed in 1924 by the State highway departments*

Group of States	Federal-aid mileage completed, fiscal year 1925	Mileage completed by State highway departments, 1924	Ratio of Federal aid to total State program
	Miles	*Miles*	*Per cent*
New England	256.2	622.9	41.2
Middle Atlantic	571.4	1,878.1	30.4
South Atlantic	1,272.7	3,240.7	39.3
East North Central	1,293.7	4,259.3	30.4
West North Central	2,561.3	5,079.3	50.5
East South Central	1,149.8	1,525.6	75.5
West South Central	2,096.1	3,187.1	65.7
Mountain	1,626.2	2,075.3	78.5
Pacific	501.2	1,295.7	38.6
Total	11,328.6	23,164.0	49.0

the highways improved under the supervision of the State highway departments are built with State funds entirely without Federal participation is sufficient to indicate that the offer of Federal assistance has not had the effect of inducing the States to spend a greater sum for highway improvement than they would otherwise have found expedient.

THE YEAR'S RECORD BY TYPES OF CONSTRUCTION

The mileage completed during the fiscal year, classified according to type of construction, is shown in Table 3.

TABLE 3.—*Mileage of Federal-aid roads completed in fiscal year 1925, by types of construction*

Class and type of construction	Completed during fiscal year 1925		
	By types	By classes	
	Miles	*Miles*	*Per cent*
Low:			
Graded and drained	2,064.1		
Sand-clay	718.8	6,985.8	61.7
Gravel	4,202.9		
Intermediate:			
Water-bound macadam	129.2		
Bituminous macadam	911.9	1,041.1	9.2
High:			
Bituminous concrete	341.3		
Portland-cement concrete	2,806.4	3,255.0	28.7
Brick	107.3		
Bridges	46.7	46.7	.4
Total	11,328.6	11,328.6	100.0

Classified in a similar manner by groups of States the completed mileage is analyzed in Table 4.

TABLE 4.—*Mileage of Federal-aid roads completed in fiscal year 1925, by classes and groups of States*

Group of States	Class of construction							
	Low		Medium		High		Bridges	
	Miles	*Per cent*	*Miles*	*Per cent*	*Miles*	*Per cent*	*Miles*	*Per cent*
New England	48.8	19.0	113.6	44.4	91.9	35.8	1.9	.8
Middle Atlantic	1.6	.3	50.4	8.8	519.3	90.9	.1	
South Atlantic	671.8	52.8	124.3	9.8	469.6	36.9	7.0	.5
East North Central	224.9	17.4	71.0	5.5	996.4	77.0	1.4	.1
West North Central	2,110.5	82.4	43.2	1.7	402.6	15.7	5.0	.2
East South Central	753.2	65.5	292.3	25.4	102.5	8.9	1.8	.2
West South Central	1,346.9	64.2	320.6	15.3	406.4	19.4	22.2	1.1
Mountain	1,494.7	91.9	5.6	.3	120.8	7.4	5.7	.4
Pacific	333.4	66.5	20.7	4.1	145.5	29.1	1.6	.3
Total	6,985.8	61.7	1,041.1	9.2	3,255.0	28.7	46.7	.4

These tables give evidence of the economy that has been exercised in the choice of types of construction. Almost a fifth of the roads built during the year were merely graded and drained; three-fifths were of the character described as low types. As will be seen from Table 4 the roads of this character have been built in those sections where traffic is still comparatively light; and in those sections they are regarded as merely the first stage of a more durable improvement which will follow as the traffic demands require it. The heavy mileage of the gravel type is especially noteworthy. This type has been found to give excellent service under automobile and light truck traffic to a maximum of about 500 vehicles a day, and it has the further advantage that it adds greatly to the life of any pavement which may subsequently be laid upon it. As suitable gravel is widely distributed in nature this type can be built at a very reasonable cost in most places.

The high-class pavements of bituminous concrete, Portland cement concrete, and brick are shown to have been constructed mainly in the Middle Atlantic, East North Central, New England, and Pacific States. It is only in these States that the traffic has developed to the point where such expensive surfaces are generally required even on the main roads. The small mileage of waterbound macadam constructed is due to the fact that this type, formerly the standard, is not suitable for motor vehicle traffic. In practically all cases the roads of this type which have been constructed will be surface-treated with bituminous material within a year to protect them from the disintegrating action of the pneumatic tires of automobiles.

NEARLY 50 MILES OF BRIDGES COMPLETED

It is especially interesting to note that the bridges completed during this fiscal year reach the impressive total of 46.7 miles in length. All these bridges are more than 20 feet in span and many of them cross major streams. More than a hundred miles of such structures have been completed with Federal aid since 1917 and projects have been approved for the construction of others which will add another 50 miles to the total length.

As stated in the last annual report, the value of Federal participation in highway construction is in no way better exemplified than in the construction of these bridges. In many cases the bridges are built at points where it has not hitherto been possible to construct them because of a lack of local funds for the purpose or because of the difficulty of obtaining joint action by counties and States in the numerous cases in which the structures span streams which form the borders of counties or States.

The careful study of lines of travel which has been made by the State and Federal authorities has developed clearly the points at which such bridges are required and the coordinating influence of the Federal Government has been the means of obtaining action toward their construction. The more important structures completed during the year are listed in Table 5.

TABLE 5.—*Federal-aid bridges completed during the fiscal year 1925 at a total cost of $75,000 or more*

State	Location between towns	Stream	Length
			Miles
Alabama	Tuscaloosa and Northport	Black Warrior River	0.1
Colorado	Pueblo and Avondale	St. Charles River	.5
Do	Delta and Grand Junction	Gunnison River	.4
Florida	Chattahoochee and Sneads	Apalachicola River	.2
Georgia (interstate)	Toccoa, Ga., and Westminster, S. C	Tugalo River	.1
Georgia	Waycross and Blackshear	Satilla River	.9
Idaho	Spalding and Lewiston	Clearwater River	.1
Idaho (interstate)	Payette, Idaho, and Ontario, Oreg	Snake River	.04
Illinois	East of Carlyle	Kaskaskia River	.6
Do	Momence and Kankakee	Kankakee River	.1
Indiana	Clay City and Jasonville	Eel River	.3
Kansas	At Drury	Chickaskia River	.2
Louisiana	Jennings and Crowley	Mermentau River	.6
Mississippi	West of Greenwood	Yazoo River	.1
Missouri	Booneville and New Franklin	Missouri River	.5
Do	Linn and Mount Sterling	Gasconade River	.1
New Mexico	Tucumcari and Logan	Canadian River	.4
North Carolina	Wilmington and Southport	Brunswick River	.1
Oklahoma	Fort Smith and a point south of Wister	Poteau River and Caston Creek.	.2
Do	Gore and Vian	Illinois River	.1
Do	Blackwell and Kildare	Chickaskia River	.1
Do	El Reno and Kingfisher	Canadian River	.1
Oregon	Near Winchester	North Umpqua River	.2
South Carolina	Spartanburg and Gaffney	Pacolet River	.1
South Dakota	Mobridge and McIntosh	Missouri River	.3
Texas	Austin and Bastrop	Colorado River	.4
Washington	Olympia and Port Angeles	Hama Hama River	.1
Total			6.94

Among the more important structures now under construction are the bridges over Raritan Bay near Perth Amboy, N. J., and two bridges over the Missouri River in Missouri. The New Jersey structure, which is 80 per cent complete, stands at one of the principal approaches to New York City. It is an essential link in the Federal-aid highway system and is especially important to traffic between the coastal section of the State and the cities of Elizabeth, Newark, Jersey City, and New York. The bridge with its approaches is 1.6 miles in length and will cost, according to the estimate, approximately $4,000,000, of which the Federal Government, because of its special and peculiar interest, will pay approximately one-third.

The special importance of the Missouri bridges is evident at a glance to anyone who will examine the map of the State. Extending entirely across the State in an easterly and westerly direction this great stream practically cuts the State in half. To establish highway communication between these sections the Federal-aid program of the State has included four major bridges of which two, one near Waverly and the other near Boonville, have been completed during this fiscal year and two are now under construction. The completed bridges were built at a combined cost of more than a million dollars with Federal participation to the extent of 50 per cent. Of the two now under construction, one near Lexington will cost alone approximately $1,300,000 and the other almost $800,000. The Federal participation in these structures is somewhat less than half the estimated cost.

As the fiscal year closes we are endeavoring to reach an agreement with the States of Arkansas and Tennessee looking to the construction of what will be one of the most important bridges in the country—that across the Mississippi River at Memphis.

FEDERAL EXPENDITURES LESS THAN 10 PER CENT OF TOTAL

The total cost of the 11,328.6 miles completed during the fiscal year was $242,937,488.57. The Federal share of the cost was $111,304,737.24. These expenditures were made over the period of approximately two years required to bring the projects to completion. They do not represent the annual expenditure for Federal-aid construction. The actual disbursements of the Federal funds to each State during the year are given in Table 6, from which it will be seen that the total disbursement was $95,749,998.11. These disbursements were made partly on account of the projects reported

TABLE 6.—*Federal-aid disbursements to States, fiscal year 1925*

State	Federal-aid disbursement	State	Federal-aid disbursement
Alabama	$2,367,059.57	New Hampshire	$553,913.21
Arizona	759,664.64	New Jersey	1,889,720.46
Arkansas	1,835,978.92	New Mexico	2,910,090.59
California	3,346,816.24	New York	4,813,177.91
Colorado	1,678,505.39	North Carolina	2,087,591.07
Connecticut	903,810.44	North Dakota	934,328.79
Delaware	385,737.26	Ohio	2,652,957.54
Florida	1,201,584.13	Oklahoma	2,852,978.73
Georgia	2,494,796.29	Oregon	1,091,482.02
Idaho	885,245.73	Pennsylvania	3,701,190.14
Illinois	3,621,054.94	Rhode Island	359,281.96
Indiana	4,184,160.40	South Carolina	1,220,841.20
Iowa	1,839,907.52	South Dakota	1,856,560.86
Kansas	2,917,961.09	Tennessee	3,079,450.10
Kentucky	1,849,055.70	Texas	5,136,128.59
Louisiana	1,243,790.76	Utah	1,554,844.27
Maine	510,283.23	Vermont	563,080.01
Maryland	621,915.84	Virginia	1,878,842.43
Massachusetts	1,369,630.31	Washington	1,101,796.53
Michigan	3,609,501.49	West Virginia	630,038.80
Minnesota	3,233,220.77	Wisconsin	1,325,077.48
Mississippi	2,171,302.47	Wyoming	1,728,033.50
Missouri	4,208,311.64	Hawaii	10,657.25
Montana	1,142,609.02		
Nebraska	1,535,989.82	Total	95,749,998.11
Nevada	1,900,041.06		

as completed during the year and partly in the form of progress payments for projects still under construction.

As will be seen from Table 6, the Federal expenditure this year closely approaches an annual rate of $100,000,000. That such a sum does not remotely approach the point of extravagance is indicated by the fact that it is not more than 10 per cent of the whole annual expenditure for highways by all units of government.

In the sparsely settled States of the West the Federal participation is a vital necessity and a definite obligation. The sections of the Federal-aid system in these States partake more of the character of interstate or national roads than of roads for local traffic. The mileage to be improved is so great that without the Federal contribution the work could not be done in a generation; and to this reason there is added the still more compelling one that is involved in the ownership of vast areas of lands by the United States which are not taxable by the States.

But the necessity for Federal participation in highway construction does not lie alone in the Far West, nor even in the Middle West and South. It is even more essential that a continuous and adequate system of highways be built in the more populous sections of the East. There is a totally erroneous impression that the roads in the East have generally been built. It is true that road improvement was begun in that section at an early date and many miles of road were built, but every mile of the original construction is being rebuilt to meet the requirements of the greatly increased traffic, and the Federal funds are as eagerly used in this section as in any other.

There is a service which should be rendered to the people of these States in particular which can not be rendered by the State governments acting separately and alone. It must be remembered that the population around the borders of the States is no less dense than in their interiors. Between the border populations of contiguous States there is a commerce which is interstate in character, though actually local in range. Nevertheless it can only be served by the unbroken continuation of roads from each State into its bordering States. It is this object, now being rapidly accomplished with Federal assistance, that the several States acting separately and alone could not have accomplished. And the Eastern States have benefited to a marked degree by this Federal service for the very reason that their population is dense and that the number of interstate roads is great. Especially in these States, it must be recognized,

that the influence of the great focal centers of population can not be obstructed at State lines. The city of Boston, for example, is the hub of New England. It centers the trade and traffic of the whole section and the highways to serve this traffic must extend through many States in unbroken continuity.

The expenditure for the roads completed during the fiscal year is analyzed by groups of States in Table 7. From this table it is apparent that the Federal funds are being utilized to practically the full extent permissible under the law in all sections. The New England, Middle Atlantic, and East North Central States are shown by this table to have spent 31.8 per cent of the total sum expended for roads completed during the year, and to have received 28.2 per cent of the Federal aid although they constitute only 13.7 per cent of the area of the United States. The States of the Mountain and Pacific groups which include 39.6 per cent of the total land area received only 18.8 per cent of the Federal aid and accounted for only 14.5 per cent of the total cost.

TABLE 7.—*Analysis of expenditures for Federal-aid roads completed in fiscal year 1925 by groups of States*

Group of States	Total cost of completed Federal-aid roads, fiscal year 1925	Federal aid to completed roads, fiscal year 1925	Average total cost per mile	Average Federal aid per mile	Percentage paid by Federal Government	Proportion of grand total cost	Proportion of grand total of Federal aid	Proportion of area
					Per cent	*Per cent*	*Per cent*	*Per cent*
New England	$11,244,053.57	$4,311,674.09	$43,900	$16,800	38.4	4.6	3.9	2.1
Middle Atlantic	27,187,500.97	9,142,753.40	47,600	16,000	33.6	11.2	8.2	3.4
South Atlantic	28,748,770.43	12,752,581.46	22,600	10,000	44.5	11.8	11.5	9.1
East North Central	38,834,920.75	17,924,902.51	30,000	13,850	46.2	16.0	16.1	8.2
West North Central	37,722,742.38	17,546,687.06	14,700	6,850	46.5	15.5	15.7	17.2
East South Central	25,949,235.84	12,374,777.65	22,600	10,750	47.7	10.7	11.1	6.0
West South Central	38,160,691.51	16,365,969.28	18,200	7,800	43.0	15.7	14.7	14.4
Mountain	21,797,180.90	13,999,018.39	13,400	8,600	64.3	9.0	12.6	28.9
Pacific	13,292,392.22	6,886,373.40	26,500	13,750	51.8	5.5	6.2	10.7
Total	242,937,488.57	111,304,737.24	21,400	9,850	45.9	100.0	100.0	100.0

FEDERAL PARTICIPATION LIMITED BY LAW IN EASTERN STATES

The lower percentage of the total cost paid by the Federal Government in the New England and Middle Atlantic States is the result of the limitation placed upon the Federal expenditure per mile of highway. Originally $10,000 per mile, this limitation was increased in 1919 to $20,000 and subsequently reduced to $16,250 for the fiscal year 1923, and to $15,000 per mile thereafter. As most of the roads completed during the past year were placed under construction a year and a half or two years ago, the Federal payments per mile reflect the provisions of the law then prevailing. An examination of the work now under way would show a still further reduction of the Federal payments per mile. This limitation is felt most keenly in the States of the Northeast. Because of the great density of traffic it is impossible to build adequate highways at a cost which can be shared equally by the Federal Government.

With the exception of the two groups referred to above and the Mountain and Pacific groups, the Federal participation ranges in all groups from 43 to practically 48 per cent of the total cost, the average for the entire country being approximately 46 per cent. The higher proportion paid in the States of the far West is made possible by the provision of the law which recognizes a greater Federal responsibility in these States because of the large holdings of public land.

Outstanding among the projects which have been made possible by this provision is the Wendover Cut-off in Utah, completed during this fiscal year. This road extending westward from Salt Lake City to the Nevada line across the Great Salt Lake Desert supplies the most difficult and almost the last link in the most direct highway connection between the east and west coasts. Its cost was $380,000, of which $284,000 was paid by the Federal Government. Since it passes through a section of the State of Utah that is practically uninhabited it is doubtful whether this essential interstate link ever would have been built but for the Government participation.

MOTOR-VEHICLE TAXES ALONE SUFFICIENT TO MATCH FEDERAL APPROPRIATIONS

That the appropriation of Federal funds on the basis of $75,000,000 a year does not unduly tax the resources of any of the States is clearly indicated by Table 8, in which it is shown that the State funds required to match the Federal apportionment of a $75,000,000 appropriation are exceeded by the revenues raised by taxation of motor vehicles and motor fuel in all States except New Mexico.

TABLE 8.—*Comparison of State motor-vehicle revenues and funds required to match Federal appropriations*

State	State funds required to match Federal appropriation of $75,000,000	Gross State income from motor vehicle license fees and gasoline taxes, calendar year 1924
Alabama	$1,541,870	$3,693,462
Arizona	403,800	1,070,560
Arkansas	1,264,164	5,101,775
California	1,628,000	19,004,335
Colorado	1,068,000	2,984,162
Connecticut	474,801	6,047,864
Delaware	365,625	908,746
Florida	892,878	6,077,610
Georgia	1,983,089	7,059,737
Idaho	628,000	1,852,564
Illinois	3,191,479	11,546,206
Indiana	1,938,693	9,028,038
Iowa	2,070,396	8,979,170
Kansas	2,074,360	4,222,930
Kentucky	1,411,607	4,894,317
Louisiana	997,262	4,125,668
Maine	685,140	2,455,811
Maryland	635,783	3,921,375
Massachusetts	1,090,118	8,122,166
Michigan	2,225,227	12,404,546
Minnesota	2,124,151	8,591,853
Mississippi	1,291,960	3,173,825
Missouri	2,417,727	4,525,914
Montana	1,193,000	1,395,615
Nebraska	1,581,969	3,597,261
Nevada	132,000	344,566
New Hampshire	365,625	2,110,031
New Jersey	935,082	9,278,428
New Mexico	690,000	616,395
New York	3,657,096	24,089,241
North Carolina	1,699,168	9,143,569
North Dakota	1,180,699	1,259,735
Ohio	2,789,588	11,685,329
Oklahoma	1,415,000	6,712,180
Oregon	710,000	7,464,848
Pennsylvania	3,360,123	31,196,917
Rhode Island	365,625	1,623,604
South Carolina	1,052,549	3,338,120
South Dakota	965,000	3,273,592
Tennessee	1,622,985	4,410,105
Texas	4,415,715	14,266,766
Utah	229,000	1,170,330
Vermont	365,625	1,554,242
Virginia	1,449,713	7,104,744
Washington	941,000	7,496,831
West Virginia	797,295	4,106,531
Wisconsin	1,873,308	6,786,485
Wyoming	525,000	648,983
Hawaii	365,625	
Total	67,081,920	304,467,082

That, in matching the Federal appropriations, the States do not incur a greater expense for highway improvement is indicated by the fact that, with two exceptions, the disbursements by the State highway departments during the calendar year 1924, exceeded the amount expended on Federal-aid roads, as shown in Table 9.

TABLE 9.—*Approximate disbursements by State highway departments in excess of expenditures for Federal-aid roads, calendar year 1924*

State	State disbursements for other than Federal-aid roads
Alabama	$1,279,000
Arizona	1,376,000
Arkansas	7,484,000
California	14,809,000
Colorado	3,050,000
Connecticut	7,430,000
Delaware	2,823,000
Florida	4,724,000
Georgia	3,021,000
Idaho	1,229,000
Illinois	33,571,000
Indiana	5,960,000
Iowa	12,791,000
Kansas	
Kentucky	9,970,000
Louisiana	5,743,000
Maine	5,420,000
Maryland	8,477,000
Massachusetts	9,760,000
Michigan	15,650,000
Minnesota	7,822,000
Mississippi	431,000
Missouri	17,469,000
Montana	128,000
Nebraska	3,189,000
Nevada	604,000
New Hampshire	2,808,000
New Jersey	17,308,000
New Mexico	1,589,000
New York	33,788,000
North Carolina	29,883,000
North Dakota	
Ohio	11,007,000
Oklahoma	958,000
Oregon	8,359,000
Pennsylvania	40,063,000
Rhode Island	2,094,000
South Carolina	3,037,000
South Dakota	1,696,000
Tennessee	4,244,000
Texas	11,880,000
Utah	1,487,000
Vermont	1,910,000
Virginia	10,771,000
Washington	4,699,000
West Virginia	12,559,000
Wisconsin	5,982,000
Wyoming	1,940,000
Total	392,272,000

MAINTENANCE THE PARAMOUNT CONSIDERATION

As previously stated, the Federal participation has in no year amounted to more than 10 per cent of the Na-

tion's total expenditure for highways, but the expenditure of these funds under joint Federal and State supervision on a limited system of major highways is rapidly connecting the States and larger communities within the States with lines of highways that are adequately built and properly maintained.

The Federal inspection of maintenance required by the Federal highway act has been of immeasurable benefit to the people of the United States. It is, if possible, more important than the original construction. Every project which has been built in part with Federal funds is inspected at frequent intervals by Federal engineers. Any that show signs of needed repairs are called to the attention of the State authorities by the Federal inspectors, and without exception the defects have been promptly remedied. This is the greatest triumph of the Federal-aid policy. The general policy of local authorities prior to the transfer of control to the State and Federal agencies was to use practically all available funds for new construction, reserving a totally inadequate amount for maintenance. Now, the proper upkeep of the highways is made the paramount consideration.

SUMMARY OF FEDERAL-AID ROAD WORK BY STATES

The construction of Federal-aid roads has now been carried on for nine years. It may therefore be desirable to summarize briefly the results that have been accomplished in each State to indicate the degree to which each has benefited by Federal participation.

Alabama.—The section of the Federal-aid highway system in this State includes 3,872 miles. All but 68 miles of the 1,153.7 miles of Federal-aid road completed are included in the system, the excluded mileage having been constructed prior to the designation of the system. Of the completed mileage 482.2 miles was added during the fiscal year 1925. At the close of the year there were 263 miles under construction and 25 miles approved but not yet under construction. The greater part of the mileage completed is surfaced with gravel or sand-clay, there being 651.1 miles of the former type and 315.9 miles of the latter. There are also 3.2 miles of earth roads graded and drained, 11.6 miles of waterbound macadam, 73.4 miles of bituminous macadam, 86.7 miles of bituminous concrete, and 9.6 miles of Portland cement concrete, The bridges completed have a combined length of 2.2 miles.

The total cost of the roads completed during the fiscal year was $8,946,220, of which the Federal share was $4,405,980. The actual disbursement of Federal funds to the State during the year was $2,367,059.

Arizona.—Arizona's section of the Federal-aid highway system includes 1,498 miles. The mileage of Federal-aid roads completed in the State up to the close of the last fiscal year was 670.5, all but 56 miles of which is included in the Federal-aid system. Of the completed mileage 132.8 miles was added during the last fiscal year. At the close of the year there were also 101 miles under construction and 33 miles approved but not yet under construction. The greater part of the completed system consists of 139.8 miles of graded and drained earth roads and 342.5 miles of gravel roads. In addition there were 55.9 miles of sand-clay, 14.2 miles of waterbound macadam, 16.5 miles of bituminous concrete and 99.4 miles of Portland cement concrete. The bridges completed have a combined length of 2.2 miles.

The total cost of the roads completed during the fiscal year was $1,685,978, of which the Federal Government paid $999,603. The actual disbursement of Federal funds to the State during the year was $759,664.

Arkansas.—The Federal-aid highway system in this State includes 5,007.03 miles. All but 55 miles of the 1,136.9 miles of Federal-aid roads completed up to the close of the year are included in this system, the excluded mileage having been constructed prior to the designation of the system. Of the completed mileage 188 miles was added during the fiscal year 1925. At the close of the year there were 299 miles under construction and 43 miles approved but not yet under construction. Of the 1,136.9 miles of roads completed up to the close of the year 727.3 miles were surfaced with gravel, 3.1 miles with sand-clay, 40.3 miles with waterbound macadam, 61.1 miles with bituminous macadam, 243.4 miles with bituminous concrete and 60.4 miles with Portland cement concrete, the balance of the completed mileage consisting of a total of 1.3 miles of bridges.

The total cost of the roads completed during the year was $4,713,282, of which the Federal Government paid $1,766,874. The actual disbursement

of Federal funds to the State during the year was $1,835,979.

California.—The California section of the Federal-aid highway system includes 4,467.6 miles. The total mileage of Federal-aid roads completed up to the close of the fiscal year 1925 was 946.9 miles, of which 152 miles built prior to the designation of the Federal-aid system are not included in the system. Of the completed mileage 265.5 miles was added during the fiscal year 1925. At the close of the year there were under construction 178 miles, and approved but not yet placed under construction 36 miles. The greater part of the completed mileage was surfaced with Portland cement concrete and gravel. Of the former type there are 359.6 miles and of the latter 209.8 miles. In addition there are 252.5 miles of earth roads graded and drained, 18.1 miles of waterbound macadam, 55.5 miles of bituminous macadam, 49.6 miles of bituminous concrete, and bridges with an aggregate length of 1.8 miles.

The total cost of the roads completed during the year was $7,378,440, of which the Federal share was $3,945,529. The actual disbursement of Federal funds to the State during the year was $3,346,816.

Colorado.—The Federal-aid highway system in Colorado includes 3,332 miles. Of this mileage there had been completed with Federal aid up to the close of the last fiscal year 712.5 miles and other Federal-aid roads completed but not included in the system have a length of 8.9 miles. Of the completed mileage 134.2 miles was added during the fiscal year 1925. At the close of the year there were 97 miles under construction and 53 miles approved but not yet placed under construction. The greater part of the completed mileage is surfaced with gravel and Portland cement concrete. Of these types there are 296.6 miles of the former and 164 miles of the latter. In addition, the completed roads include 171.4 miles of graded and drained earth roads, 75.8 miles of sand-clay, and 1 mile of bituminous concrete, and the bridges completed have an aggregate length of 3.7 miles.

The total cost of the roads completed during the fiscal year was $3,678,153, of which the Federal Government paid $1,960,296. The actual disbursement of Federal funds to the State during the year was $1,678,505.

Connecticut.—The section of the Federal-aid highway system in this State includes 835.43 miles. Of this mileage 118.4 miles had been completed up to the close of the fiscal year with Federal aid and no Federal-aid roads had been built which were not included in the system. The roads completed during the last fiscal year amount to 36.6 miles and there were under construction at the close of the year 14 miles additional, besides which there were 6.2 miles approved but not yet under construction. The completed mileage includes 82.6 miles of Portland cement concrete, 27 miles of bituminous macadam and 8.8 miles of waterbound macadam.

The total cost of the roads completed during the fiscal year was $2,170,514, of which the Federal Government paid $703,795. The actual disbursement of Federal funds to the State during the year was $903,810.

Delaware.—The Federal-aid highway system of Delaware includes 335.43 miles. This is one of the States in which the original 7 per cent system has been completed and additions have been authorized. A considerable part of the system has been built by the State without Federal aid, but up to the close of the fiscal year there had been completed with Federal participation 115.7 miles, all of which is included in the Federal-aid system. Of this completed mileage 31.4 miles was built during the last year and at the close of the year there were under construction an additional 4 miles, and approved but not yet under construction 19 miles more. With the exception of 6.2 miles surfaced with brick and 0.2 mile which consists of a bridge, all the Federal-aid roads completed in this State have been surfaced with Portland cement concrete, there being 109.3 miles of this type.

The total cost of the roads completed during the fiscal year was $1,169,291, of which the Federal Government paid $465,084. The actual disbursement of Federal funds to the State during the year was $385,737.

Florida.—The section of the Federal-aid highway system in this State includes 1,901 miles. All but 22 miles of the 212.8 miles completed are included in the system, the excluded mileage having been constructed prior to the designation of the system. Of the completed mileage 100.2 miles was added during the fiscal year 1925 and in addition there were under construction at the close of the year 135 miles, and approved but not yet under construction a bridge with a length of 0.1 mile. The completed roads consist of 20 miles of graded and drained earth, 34.1 miles of sand-clay, 64.8

miles of bituminous macadam, 12.8 miles of bituminous concrete, 70.7 miles of Portland cement concrete, 10.1 miles of brick, in addition to which there are bridges with a total length of 0.3 mile.

The total cost of the roads completed during the fiscal year was $3,328,705, of which the Federal share was $1,627,053. The actual disbursement of Federal funds to the State during the year was $1,201,584.

Georgia.—The Georgia section of the Federal-aid highway system includes 5,557.9 miles. The Federal-aid roads completed up to the close of the fiscal year 1925 have a total length of 1,652.8 miles, but 105 miles included in this total were built prior to the designation of the Federal-aid system and are not included in it. Three hundred and twenty-six miles were completed during the last fiscal year and at the close of the year 566 miles were under construction and 35 miles were approved for construction. The greater part of the completed mileage is surfaced with sand-clay, there being 1,055.5 miles of this type. Of other roads completed there are 73.6 miles of graded and drained earth, 286.2 miles of gravel, 27.4 miles of waterbound macadam, 69.1 miles of bituminous macadam, 11.6 miles of bituminous concrete, 109.9 miles of Portland cement concrete and 0.5 mile of brick. Bridge construction in this State has been carried on to a greater extent than in any other with the exception of Texas, the completed bridges having a total length of 19 miles.

The total cost of the roads completed during the fiscal year was $4,306,914, of which $2,118,847 was paid by the Federal Government. The actual disbursement of Federal funds to the State during the year was $2,494,796.

Idaho.—Idaho's section of the Federal-aid highway system includes 2,768.6 miles. The Federal-aid roads completed up to the close of the year have a total length of 639.9 miles, and only 24 miles of this total are not on the Federal-aid system. The mileage completed during the year was 113.1 miles. At the close of the year there were under construction 115 miles and approved for construction 37 miles. In this State, where traffic is relatively light, the greater part of the completed mileage consists of roads surfaced with gravel, there being 402.8 miles of this type. In addition, there are 158.6 miles of graded and drained earth roads, 18.8 miles of sand-clay, 4.3 miles of waterbound macadam, 33 miles of bituminous concrete, and 21.3 miles of Portland cement concrete. Bridges completed up to the close of the fiscal year have a total length of 1.1 miles.

The total cost of the roads completed during the fiscal year was $1,287,097, of which the Federal Government paid $771,199. The actual disbursement of Federal funds to the State during the year, however, was $885,245.

Illinois.—The Federal-aid highway system of Illinois includes 5,002.2 miles. The sections of the system completed up to the close of the fiscal year with Federal aid have a total length of 1,284.7 miles, and no Federal-aid roads have been built which are not on the system. Of this completed mileage 370.5 miles was added during the fiscal year 1925. At the close of the year there were 222 miles under construction and 17 miles approved for construction. Nearly the entire completed mileage is surfaced with Portland cement concrete, there being 1,114.8 miles of this type. In addition there are 138.1 miles of graded and drained earth roads, 0.4 mile of gravel, 3.3 miles of bituminous macadam, 8.1 miles of bituminous concrete, and 18.6 miles surfaced with brick. Bridges completed in the State have a total length of 1.4 miles.

The total cost of the roads completed during the fiscal year was $10,931,911, of which the Federal Government paid $5,285,725. The actual disbursement of Federal funds to the State during the year was $3,621,054.

Indiana.—The Indiana section of the Federal-aid highway system includes 4,679 miles. With the exception of 2.5 miles the Federal-aid roads completed up to the close of the fiscal year 1925, of which there are 530 miles, are included in the system. The roads completed during the fiscal year have a total length of 266.8 miles and at the close of the year there were 325 miles under construction and 23 miles approved but not yet under construction. In this State, as in the neighboring State of Illinois, the greater part of the completed mileage is surfaced with Portland cement concrete. There are 445 miles of this type, in addition to 19.8 miles of graded and drained earth, 27.1 miles of gravel, 7.5 miles of waterbound macadam, 17 miles of bituminous macadam, and 12 miles of bituminous concrete. Bridges completed up to the close of the year have a total length of 1.6 miles.

The total cost of the roads completed during the fiscal year was $8,312,508, of which the Federal Government paid $4,027,473. The actual disbursement of Federal funds to the State during the year was $4,184,160.

Iowa.—The Iowa section of the Federal-aid highway system includes 7,231 miles. All Federal-aid roads completed up to the close of the fiscal year, of which there are 2,038.2 miles, are included in the system. The mileage completed during the fiscal year was 349.6 miles. At the close of the year there were 393 miles additional under construction, and 90 miles approved for construction. The greater part of the mileage completed in this State consists of graded and drained earth roads, there being 1,251.6 miles of this type which have been built as the first stage of an improvement which, as funds become available, will be completed by surfacing. In addition to the graded roads, there are 389.4 miles surfaced with gravel, 375 miles paved with Portland cement concrete and 22 miles with brick. Bridges completed up to the close of the fiscal year have a total length of 0.2 mile.

The total cost of the roads completed during the year was $4,209,963, of which the Federal Government paid $1,939,561. The actual disbursement of Federal funds to the State during the year was $1,839,907.

Kansas.—The Kansas section of the Federal-aid highway system includes 7,516 miles. All Federal-aid roads completed up to the close of the year, of which there were 994.5 miles, are included in the system. Of this completed mileage 337 miles was added during the fiscal year 1925. At the close of the year there were 437 miles under construction and 13 miles approved for construction. Of the mileage completed up to the close of the year there were 181.6 miles of graded and drained earth roads, 88 miles of sand-clay, 125.2 miles of gravel, 4.5 miles of waterbound macadam, 56.5 miles of bituminous macadam, 431.4 miles of Portland cement concrete, 105.6 miles of brick, and the bridges completed have a total length of 1.7 miles.

The total cost of the roads completed during the fiscal year was $8,265,215, of which the Federal share was $3,593,498. The actual disbursement of Federal funds to the State during the year was $2,917,961.

Kentucky.—Kentucky's section of the Federal-aid highway system includes 3,639.95 miles, of which, up to the close of the fiscal year 1925, 598.6 miles had been completed with Federal aid. Of this completed mileage 145.7 miles was added during the fiscal year 1925. At the close of the year there were 285 miles under construction and 40 miles approved for construction. The roads completed include 335.8 miles of graded and drained earth, 69.2 miles of gravel, 41.1 miles of waterbound macadam, 105.8 miles of bituminous macadam, 42 miles of Portland cement concrete, and 3.9 miles of brick. Bridges completed up to the close of the fiscal year have a total length of 0.8 mile.

The total cost of the roads completed during the year was $4,159,571, of which the Federal share is $1,662,848. The actual disbursement of Federal funds to the State during the year was $1,849,055.

Louisiana.—There are 2,771 miles in Louisiana's section of the Federal-aid highway system. The Federal-aid roads completed up to the close of the fiscal year 1925 have a total length of 1,025.5 miles, of which all but 103 miles completed prior to the designation of the Federal-aid system, are included in the system. Of the completed mileage 324.4 miles was added during the last fiscal year. At the close of the year there were 72 miles under construction and 3 miles approved for construction. The greater part of the mileage completed is surfaced with gravel, there being 996.2 miles of this type. In addition, the completed mileage includes 7.4 miles of graded and drained earth, 3.2 miles of waterbound macadam, 9.5 miles of bituminous macadam, and 7.6 miles of bituminous concrete, and the bridges completed have a total length of 1.6 miles.

The total cost of the roads completed during the fiscal year was $4,538,345, of which the Federal share was $2,195,490. The actual disbursement of Federal funds to the State during the year was $1,243,790.

Maine.—The section of the Federal-aid highway system in Maine includes 1,393.46 miles. All Federal-aid roads completed up to the close of the last fiscal year, of which there were 288 miles, are included in the system. Fifty-one miles were added to the system during the last fiscal year and at the close of the year there were 35 miles under construction. The greater part of the mileage completed was surfaced with gravel and bituminous macadam, there being 120.5 miles of the former type and 128 miles of the latter. In addition to these roads

there were only 39.3 miles surfaced with Portland cement concrete. The bridges completed up to the close of the year have a total length of 0.2 mile.

The total cost of the roads completed during the fiscal year was $1,330,369, of which the Federal share was $641,229. The actual disbursement of Federal funds to the State during the year was $510,283.

Maryland.—The Maryland section of the Federal-aid highway system includes 1,417.48 miles. The Federal-aid roads completed in the State up to the close of the fiscal year have a total length of 320 miles, of which, however, 63.4 miles completed prior to the designation of the Federal-aid highway system is not included in the system. Of the completed Federal-aid mileage 67.3 miles was added during the fiscal year 1925. At the close of the year there were under construction 31 miles and approved for construction 85 miles. The greater part of the mileage completed up to the close of the fiscal year was paved with Portland cement concrete, there being 230.7 miles of this type, besides which there are 3.8 miles of graded and drained earth roads, 31.5 miles surfaced with gravel, 0.1 mile of waterbound macadam, 41.6 miles of bituminous macadam, and 12.3 miles of bituminous concrete.

The total cost of the roads completed during the fiscal year was $1,937,750, of which the Federal share was $878,368. The actual disbursement of Federal funds to the State during the year was $621,915.

Massachusetts.—The Federal-aid highway system in Massachusetts includes 1,3[illegible]8 miles. All but 23 miles of the 328.[illegible] miles of Federal-aid roads completed up to the close of the last fiscal year are included in the system. During the last fiscal year the mileage completed was 74.5 miles. In addition, there were under construction at the close of the year 56 miles and approved for construction 11 miles. The completed roads consist of 184.4 miles of bituminous macadam, 109.7 miles of Portland cement concrete, 30.2 miles of bituminous concrete, and 3.3 miles of waterbound macadam, and the bridges completed have a total length of 1.3 miles.

The total cost of the roads completed during the fiscal year was $4,280,919, of which the Federal share was $1,474,831. The actual disbursement of Federal funds to the State during the year was $1,369,630.

Michigan.—The Michigan section of the Federal-aid highway system includes 4,768 miles. In this State there had been completed up to the close of the last fiscal year 861.7 miles of Federal-aid roads, all but 19 miles of which is included in the Federal-aid system. Of the completed mileage 287.8 miles was added during the last fiscal year. At the close of the year there were 226 miles under construction. The greater part of the completed mileage is surfaced with Portland cement concrete and gravel, there being of the former type 415.8 miles and of the latter 319.8 miles. In addition, there are 25.7 miles of graded and drained earth roads, 18.9 miles of waterbound macadam, 5 miles of bituminous macadam, 76.1 miles of bituminous concrete, and 0.4 mile of brick.

The total cost of the roads completed during the fiscal year was $7,104,249, of which the Federal share was $3,321,499. The actual disbursement of Federal funds to the State during the year was $3,609,501.

Minnesota.—The Federal-aid highway system in Minnesota includes 6,849.6 miles. The Federal-aid roads completed up to the close of the fiscal year have a total length of 2,721.2 miles, all of which, with the exception of 192 miles completed prior to the designation of the system, are included in the Federal-aid highway system. Of the mileage completed, 411 miles was added during the last fiscal year and at the close of the year there were 684 miles under construction and 146 miles approved for construction. The mileage completed in this State is greater than in any State with the exception of Texas, and the greater part of it is surfaced with gravel, there being 1,970.7 miles of this type. There are also 466.1 miles of graded and drained earth roads, 22.1 miles of bituminous concrete and 261.9 miles of Portland cement concrete. Bridges completed up to the close of the fiscal year have a total length of 0.4 mile.

The total cost of the roads completed during the fiscal year was $6,424,894, of which the Federal share was $2,848,805. The actual disbursement for Federal funds to the State during the year was $3,233,220.

Mississippi.—The section of the Federal-aid highway system in Mississippi includes 3,329 miles. Of the 872.5 miles of Federal-aid roads completed up to the close of the fiscal year 108 miles are not included in the sys-

tem. These roads were projected and built prior to the designation of the system in 1921. Of the total completed mileage 217.5 miles was added during the last year. At the close of the year 422 miles additional were under construction and 42 miles were approved for construction. The greater part of the mileage completed was surfaced with gravel, there being 569.1 miles of this type. The balance of the completed mileage consists of 181.7 miles of graded and drained earth roads, 17.6 miles of sand-clay, 11.1 miles of waterbound macadam, 1 mile of bituminous macadam, 9.2 miles of bituminous concrete, 73.4 miles of Portland cement concrete and 9.2 miles paved with brick. Bridges completed in the State up to the close of the fiscal year have a total length of 0.2 mile.

The total cost of the roads completed during the fiscal year was $3,487,896, of which the Federal share was $1,701,759. The actual disbursement of Federal funds to the State during the year was $2,171,302.

Missouri.—The Federal-aid highway system in Missouri includes 7,530 miles, and, with the exception of 32 miles completed prior to the designation of the system, the entire mileage of Federal-aid roads completed up to the close of the fiscal year, amounting to 1,349.6 miles, is included in the system. Of the completed mileage 443.5 miles was added during the last fiscal year. At the close of the year there were under construction 638 miles and approved for construction 18 miles. The completed roads are mainly of three types, the greatest mileage being surfaced with gravel, of which there are 708 miles. In addition there are 300.1 miles of graded and drained earth roads, 252.3 miles of Portland cement concrete, 13.4 miles of waterbound macadam, 48.9 miles of bituminous macadam, 17.7 miles of bituminous concrete, and 6.2 miles of brick. The bridges completed with Federal aid have a total length of 3 miles.

The total cost of the roads completed during the fiscal year was $9,808,732, of which the Federal share was $4,780,497. The actual disbursement of Federal funds to the State during the year was $4,208,311.

Montana.—The Montana section of the Federal-aid highway system includes 4,366 miles. The Federal-aid roads completed up to the close of the fiscal year have a total length of 937.7 miles, but 193 miles constructed prior to the designation of the system are not included in it. Of the completed mileage 132 miles was built during the last fiscal year and at the close of the year there were under construction 167 miles and approved for construction 117 miles. The larger part of the completed mileage is surfaced with gravel, there being 664.9 miles of this type. There are also 215.8 miles of graded and drained earth roads, 16 miles of waterbound macadam, 6.9 miles of bituminous macadam, 0.9 mile of bituminous concrete, and 31.3 miles of Portland cement concrete. The bridges completed have a total length of 1.9 miles.

The total cost of the roads completed during the fiscal year was $1,462,935, of which the Federal share was $1,024,548. The actual disbursement of Federal funds to the State during the year was $1,142,609.

Nebraska.—The Nebraska section of the Federal-aid highway system includes 5,489 miles. All but 19.3 miles of the 1,874.7 miles of Federal-aid roads completed up to the close of the fiscal year are included in the system. Of the total mileage completed 155.8 miles was completed during the last fiscal year and at the close of the year there were 545 miles under construction and 43 miles approved for construction. The completed mileage includes 1,454.1 miles of graded and drained earth roads, 141.5 miles of sand-clay, 217.1 miles of gravel, 9.4 miles of bituminous concrete, 37.4 miles of Portland cement concrete, and 14.3 miles paved with brick. The bridges completed up to the close of the year have a total length of 0.9 mile.

The total cost of the roads completed during the fiscal year was $2,656,656, of which the Federal share was $1,276,615. The actual disbursement of Federal funds to the State during the year was $1,535,989.

Nevada.—The Nevada section of the Federal-aid highway system includes 1,434 miles. The roads completed with Federal aid up to the close of the fiscal year have a total length of 427.8 miles, and with the exception of 25 miles constructed prior to the designation of the system this entire mileage is included in it. The mileage completed during the last fiscal year amounts to 145.3 miles, and at the close of the year there were under construction 379 miles and approved for construction 17 miles. The completed mileage includes 265.4 miles of gravel, 73.5 miles of graded and drained earth roads, 24.9 miles of sand-clay, 20.6 miles of bituminous mac-

adam, 1.6 miles of bituminous concrete, and 40.4 miles of Portland cement concrete. Bridges built up to the close of the fiscal year have a total length of 1.4 miles.

The total cost of the roads completed during the fiscal year was $2,087,851, of which the Federal share was $1,700,958. The actual disbursement of Federal funds to the State during the year was $1,900,041.

New Hampshire.—The Federal-aid highway system in New Hampshire includes 977.39 miles. The roads completed with Federal aid up to the close of the fiscal year have a total length of 215 miles, of which all but 17 miles is included in the Federal-aid system. The mileage completed during the last fiscal year amounts to 38.8 miles. At the close of the year there were under construction 22 miles additional and approved for construction 6 miles. The completed mileage includes 94.8 miles of gravel roads, 32 miles of waterbound macadam, 52.8 miles of bituminous macadam, 30 miles of bituminous concrete, and 4.3 miles of Portland cement concrete. The completed bridges have a total length of 1.1 miles.

The total cost of the roads completed during the fiscal year was $1,147,421, of which the Federal share was $531,483. The actual disbursement of Federal funds to the State during the year was $553,913.

New Jersey.—New Jersey's section of the Federal-aid highway system includes 1,198.3 miles. Of this mileage 229.6 miles have been completed with Federal aid, of which 70.4 miles were completed during the last fiscal year. At the close of the year 53 miles were under construction and 19 miles were approved for construction. The greater part of the completed mileage of this State is paved with Portland cement concrete, there being 211.9 miles of this type. In addition there are 1.6 miles of graded and drained earth roads, 3.4 miles of gravel, and 12.6 miles of bituminous concrete, and one bridge with a total length of 0.1 mile.

The total cost of the roads completed during the fiscal year was $4,802,169, of which the Federal share was $1,158,534. The actual disbursement of Federal funds to the State during the year was $1,889,720.

New Mexico.—The New Mexico section of the Federal-aid highway system includes 3,250 miles. Federal-aid roads completed up to the close of the fiscal year have a total length of 1,353 miles, but 252 miles completed prior to the designation of the system are not included. During the last fiscal year 473.4 miles have been completed and at the close of the year there were under construction 123 miles and approved for construction 12 miles. The completed roads are largely of the gravel type, there being of this character 1,065.3 miles. In addition, there are 221.8 miles of graded and drained earth roads, 5.1 miles of sand-clay, 0.7 mile of bituminous concrete, and 59.3 miles of Portland cement concrete. The bridges completed up to the close of the fiscal year have a total length of 0.8 mile.

The total cost of the roads completed during the fiscal year was $5,008,465, of which the Federal share was $3,340,291. The actual disbursement of Federal funds to the State during the year was $2,910,090.

New York.—The section of the Federal-aid highway system in New York has a total length of 5,012 miles. Federal-aid roads completed up to the close of the fiscal year amount to 972 miles, but 442 miles completed prior to the designation of the system are not included in it. The mileage completed during the last fiscal year was 344.4 miles, and there were under construction at the close of the year 487 miles and approved for construction 118 miles. The entire completed mileage is surfaced with one or the other of four high types of surfacing. A total of 697.1 miles is paved with Portland cement concrete, 267.9 miles are surfaced with bituminous macadam, 4.8 miles with bituminous concrete, and 0.7 mile with brick. The total length of the bridges completed up to the close of the year was 1.5 miles.

The total cost of the roads completed during the fiscal year was $13,779,859, of which the Federal share was $5,548,190. The actual disbursement of Federal funds to the State during the year was $4,813,178.

North Carolina.—The Federal-aid highway system in North Carolina includes 3,790.3 miles. Up to the close of the fiscal year the mileage of Federal-aid roads completed was 1,178.5 miles, of which all but 145 miles was included in the Federal-aid highway system, the excluded mileage having been constructed prior to the designation of the system. Of the completed

mileage 173.4 miles was added during the fiscal year. At the close of the year there were 158 miles under construction and 43 miles approved for construction. The completed mileage consisted of 76.1 miles of graded and drained earth roads, 590.4 miles of sand-clay, 85.8 miles of gravel, 12.8 miles of waterbound macadam, 38 miles of bituminous macadam, 141.5 miles of bituminous concrete and 232.3 miles of Portland cement concrete. The bridges completed up to the close of the year have a total length of 1.6 miles.

The total cost of the roads completed during the fiscal year was $6,475,468, of which the Federal share was $2,440,273. The actual disbursement of Federal funds to the State during the year was $2,087,591.

North Dakota.—The section of the Federal-aid highway system in North Dakota includes 6,154 miles. All but 84 miles of the 2,015.3 miles of Federal-aid roads completed up to the close of the fiscal year were included in the system, the excluded mileage having been constructed prior to the designation of the system. Of the completed mileage 381.1 miles was added during the fiscal year 1925 and at the close of the year there were under construction 369 miles and approved for construction 95 miles. The greater part of the completed mileage is of two types, there being 1,648 miles of graded and drained earth roads and 355 miles of gravel. In addition there are 6.5 miles of sand-clay roads, 1.2 miles of bituminous concrete, and 3 miles of Portland cement concrete. The bridges completed up to the close of the year have a total length of 1.6 miles.

The total cost of the roads completed during the fiscal year was $2,554,397, of which the Federal share was $1,230,646. The actual disbursement of Federal funds to the State during the year was $934,328.

Ohio.—Ohio's section of the Federal-aid highway system includes 5,798.5 miles. The Federal-aid roads completed up to the close of the fiscal year have a total length of 1,225.6 miles, of which 82 miles are not included in the Federal-aid highway system, having been completed prior to the designation of the system. Of the completed mileage 240.8 miles was added during the fiscal year 1925 and at the close of the year 250 miles were under construction and 100 miles were approved for construction. The completed mileage consists of 393.4 miles of Portland cement concrete roads 380.9 miles paved with brick, 88.1 miles surfaced with bituminous concrete, 246.3 miles of bituminous macadam, 82.6 miles of waterbound macadam, and 34.2 miles of graded and drained earth roads. The bridges completed have a length of only 0.1 mile.

The total cost of the roads completed during the fiscal year was $8,899,524, of which the Federal share was $3,548,113. The actual disbursement of Federal funds to the State during the year was $2,652,957.

Oklahoma.—The section of the Federal-aid highway system in Oklahoma includes 5,573 miles. Of the 910.2 miles of Federal-aid roads completed up to the close of the fiscal year all but 8.6 miles are included in the system, the latter mileage having been constructed prior to the designation of the system. Of the completed mileage 412.9 miles, or nearly one-half, was completed during the fiscal year and at the close of the year there were 254 miles under construction and 47 miles approved for construction. The completed roads consist of 40.4 miles of graded and drained earth roads, 2.3 miles of sand-clay, 526.7 miles of gravel, 6.3 miles of waterbound macadam, 0.6 mile of bituminous macadam, 64.5 miles of bituminous concrete, 257.5 miles of Portland cement concrete, and 4 miles of brick. The bridges have a total length of 7.9 miles.

The total cost of the roads completed during the fiscal year was $9,420,729, of which the Federal share was $4,532,987. The actual disbursement of Federal funds to the State during the year was $2,852,978.

Oregon.—The Oregon section of the Federal-aid highway system includes 2,814 miles. The Federal-aid roads completed up to the close of the fiscal year have a total length of 829.2 miles, all of which is included in the Federal-aid system. Of the completed mileage 153 miles were completed during the fiscal year and at the close of the year there were 102 miles under construction and 39 miles approved for construction. The completed mileage consists of 553.7 miles of gravel, 110.2 miles of graded and drained earth roads, 25.6 miles of waterbound macadam, 52.9 miles of bituminous concrete, and 85.7 miles of Portland

cement concrete. The bridges completed up to the close of the year have a total length of 1.1 miles.

The total cost of the roads completed during the fiscal year was $2,618,037, of which the Federal share was $1,510,345. The actual disbursement of Federal funds to the State during the year was $1,091,482.

Pennsylvania.—Pennsylvania's section of the Federal-aid highway system includes 3,670.55 miles. All but 2.5 miles of the Federal-aid roads completed up to the close of the fiscal year 1925, amounting to 987.6 miles, are included in the system. Of the completed mileage 156.6 miles was added during the fiscal year and at the close of the year 392 miles were under construction and 155 miles approved for construction. The entire completed mileage in this State is surfaced with one of the higher types of pavement. There are 852.7 miles of Portland cement concrete, 101.9 miles of bituminous concrete, 25.2 miles of brick, and 7.8 miles of bituminous macadam. No bridges have been built in this State with Federal aid.

The total cost of the roads completed during the fiscal year was $8,605,472, of which the Federal share was $2,436,028. The actual disbursement of Federal funds to the State during the year was $3,701,190.

Rhode Island.—The section of the Federal-aid highway system in Rhode Island includes 234.13 miles, which is in excess of 7 per cent of the total highway mileage of the State, as a result of extensions authorized on the completion of the original 7 per cent system. Up to the close of the fiscal year there had been completed in the State with Federal aid 70.8 miles, all of which was included in the Federal-aid system, and of this mileage 21.7 miles had been added during the fiscal year. At the close of the year there were under construction 20 miles and approved for construction 9 miles. The entire completed mileage was surfaced with one of the higher types of pavement, there being 37 miles of bituminous concrete, 23.3 miles of Portland cement concrete, and 10.5 miles of bituminous macadam. No bridges have been constructed with Federal aid.

The total cost of the roads completed during the fiscal year was $1,202,132, of which the Federal share was $440,391. The actual disbursement of Federal funds to the State during the year was $359,282.

South Carolina.—The section of the Federal-aid highway system in South Carolina includes 3,150 miles. At the close of the fiscal year 1925, 1,311.1 miles of Federal-aid roads had been completed, of which 103.5 miles completed prior to the designation of the Federal-aid system are not included in it. Of the completed mileage 275.5 miles had been added during the fiscal year 1925, and at the close of the year there were under construction 298 miles and approved for construction 35 miles. The completed mileage includes 10.8 miles of graded and drained earth roads, 1,105.4 miles of sand-clay roads, 100.9 miles of gravel, 3 miles of bituminous macadam, 38 miles of bituminous concrete, 49 miles of Portland cement concrete, and 0.2 mile of brick. The bridges completed in the State have a total length of 3.8 miles.

The total cost of the roads completed during the fiscal year was $3,158,766, of which the Federal share was $1,285,212. The actual disbursement of Federal funds to the State during the year was $1,220,841.

South Dakota.—South Dakota's section of the Federal-aid highway system includes 5,666 miles. The mileage of Federal-aid roads completed up to the close of the fiscal year 1925 was 1,579.9 miles, of which all but 20.9 miles was included in the Federal-aid system. Of the completed mileage 483.3 miles, or almost 30 per cent, was added during the last fiscal year. At the close of the year there were under construction 879 miles and approved for construction 55 miles. The greater part of the completed mileage was surfaced with gravel, there being 1,293.8 miles of this type. In addition there were 281.7 miles of graded and drained earth roads, 2.5 miles of sand-clay and 0.8 mile of Portland cement concrete. The bridges completed up to the close of the fiscal year have a total length of 1.1 miles.

The total cost of the roads completed during the fiscal year was $3,802,882, of which the Federal share was $1,877,063. The actual disbursement of Federal funds to the State during the year was $1,856,560.

Tennessee.—The section of the Federal-aid highway system in Tennessee includes 3,180.2 miles. The Federal-aid roads completed up to the close of

the fiscal year have a total length of 596.5 miles, of which all but 37 miles completed prior to the designation of the Federal-aid highway system are included in the system. Of the completed mileage 304.4 miles, or more than 50 per cent, was added during the last fiscal year. At the close of the year there were under construction 324 miles. The completed mileage includes 363.4 miles of bituminous macadam, 94.4 miles of gravel, 50.8 miles of Portland cement concrete, 52.3 miles of waterbound macadam, 21.9 miles of bituminous concrete and 13.1 miles of graded and drained earth roads. The bridges completed have a combined length of 0.6 mile.

The total cost of the roads completed during the fiscal year was $9,355,548, of which the Federal share was $4,604,189. The actual disbursement of Federal funds to the State during the year was $3,079,450.

Texas.—Texas, the largest State in the Union, has the largest section of the Federal-aid highway system, including 10,932 miles. Of the Federal-aid roads completed, amounting to 4,332.3 miles, all but 327 miles, completed prior to the designation of the Federal-aid highway system, are included in it. Of the completed mileage 1,170.8 miles was added during the last fiscal year and at the close of the year there were under construction 1,084 miles and approved for construction 185 miles. The greater part of the completed mileage was surfaced with gravel, there being 2,756.2 miles of this type. In addition, the completed mileage includes 303.8 miles of graded and drained earth roads, 61.2 miles of sand-clay, 448 miles of waterbound macadam, 309.3 miles of bituminous macadam, 77.7 miles of bituminous concrete, 329.5 miles of Portland cement concrete, and 24.8 miles of brick. Up to the close of the fiscal year the bridges had a combined length of 21.8 miles.

The total cost of the roads completed during the fiscal year was $19,488,335, of which the Federal share was $7,870,617. The actual disbursement of Federal funds to the State during the year was $5,136,128.

Utah.—The Federal-aid highway system of Utah includes 1,588 miles. Of the 487.4 miles of Federal-aid roads completed up to the close of the fiscal year 167 miles completed prior to the designation of the system are not included in it. During the fiscal year 169.9 miles were completed and at the close of the year 162 miles were under construction and 25 miles were approved for construction. The completed mileage consists of 242.3 miles of gravel, 101.1 miles of graded and drained earth roads, 37.6 miles of sand-clay, 9.3 miles of waterbound macadam, 7.8 miles of bituminous concrete, and 88 miles of Portland cement concrete. The bridges completed up to the close of the fiscal year have a total length of 1.3 miles.

The total cost of the roads completed during the fiscal year was $3,167,835, of which the Federal share was $2,102,039. The actual disbursement of Federal funds to the State during the year was $1,554,844.

Vermont.—Vermont's section of the Federal-aid highway system includes 1,043 miles. With the exception of 1 mile constructed prior to the designation of the system, all Federal-aid roads completed up to the close of the fiscal year 1925, amounting to 108 miles, were included in the system. Of the completed mileage 33.6 miles were added during the fiscal year 1925, and at the close of the year 26 miles were under construction and 9 miles were approved for construction. The completed mileage includes 72.8 miles of gravel roads, 3.4 miles of waterbound macadam, 19.7 miles of bituminous macadam, and 10.8 miles of Portland cement concrete. The bridges completed have a combined length of 1.3 miles.

The total cost of roads completed during the fiscal year was $1,112,697, of which the Federal share was $519,944. The actual disbursement of Federal funds to the State during the year was $563,080.

Virginia.—The Federal-aid highway system in Virginia includes 3,075.5 miles. The Federal-aid roads completed up to the close of the last fiscal year have a total length of 859.6 miles, of which all but 43 miles are included in the Federal-aid system. Of the completed mileage 238.8 miles were completed during the last fiscal year and at the close of the year 165 miles were under construction and 59 miles were approved for construction. The completed roads include 241.6 miles of Portland cement concrete, 186.2 miles of bituminous macadam, 199.7 miles of sand-clay, 108.5 miles of waterbound macadam, 84.7 miles of gravel, 27 miles of graded and drained earth roads, and 10.6 miles of bituminous concrete. The bridges completed have a total length of 1.3 miles.

The total cost of the roads completed during the fiscal year was $7,017,132, of which the Federal share was $3,279,419. The actual disbursement of Federal funds to the State during the year was $1,878,842.

Washington.—The Washington section of the Federal-aid highway includes 2,907.7 miles. All but 12 miles of the 551.9 miles of Federal-aid roads completed up to the close of the fiscal year 1925 were included in the Federal-aid system. Of the total mileage completed 82.7 miles were added during the fiscal year, and at the close of the year 102 miles were under construction and 22 miles were approved for construction. The completed mileage includes 200.9 miles of Portland cement concrete, 296.8 miles of gravel, and 52.4 miles of graded and drained earth roads. The bridges completed up to the close of the year have a combined length of 1.8 miles.

The total cost of the roads completed during the fiscal year was $3,295,914, of which the Federal share was $1,430,498. The actual disbursement of Federal funds to the State during the year was $1,101,796.

West Virginia.—The West Virginia section of the Federal-aid highway system includes 1,918.5 miles. Of the 335.9 miles of Federal-aid roads completed up to the close of the fiscal year 74 miles completed prior to the designation of the Federal-aid highway system are not included in it. The mileage completed during the last fiscal year was 60.1 miles and at the close of the year there were 140 miles under construction and 50 miles approved for construction. The completed mileage includes 138.5 miles of graded and drained earth roads, 1.7 miles of sand-clay, 18.3 miles of gravel, 4.9 miles of waterbound macadam, 69.7 miles of bituminous macadam, 16.3 miles of bituminous concrete, 74.9 miles of Portland cement concrete, and 11.4 miles paved with brick. The bridges completed up to the close of the fiscal year have a length of 0.2 mile.

The total cost of the roads completed during the fiscal year was $1,354,742, of which the Federal share was $658,321. The actual disbursement of Federal funds to the State during the year was $630,039.

Wisconsin.—The section of the Federal-aid highway system in Wisconsin includes 5,493.36 miles. Up to the close of the year 1,484.6 miles of Federal-aid roads had been completed, but 267 miles completed prior to the designation of the Federal-aid system are not included in it. Of the completed mileage 127.8 miles were completed during the last fiscal year, and at the close of the year 147 miles were under construction and 90 miles approved for construction. The completed mileage includes 731.9 miles of gravel roads, 366.3 miles of Portland cement concrete, 233.6 miles of graded and drained earth roads, 140.5 miles of sand-clay, 9.6 miles of bituminous macadam, and 2.7 miles of waterbound macadam. The bridges completed up to the close of the year have a length of 0.1 mile.

The total cost of the roads completed during the fiscal year was $3,586,726, of which the Federal share was $1,742,090. The actual disbursement of Federal funds to the State during the year was $1,325,077.

Wyoming.—Wyoming's section of the Federal-aid highway system includes 3,071.7 miles. The Federal-aid roads completed up to the close of the year have a total length of 1,037.8 miles, of which all but 59 miles completed prior to the designation of the Federal-aid highway system are not included in it. Of the completed mileage 325.5 miles, or approximately 30 per cent of the total, was added during the last fiscal year. At the close of the year the roads under construction had a total length of 201 miles and 54 miles were approved for construction. The completed mileage includes 462.3 miles of sand-clay, 310.8 miles of graded and drained earth roads, 246.2 miles of gravel, 1.2 miles of bituminous concrete, and 14.3 miles of Portland cement concrete. The bridges completed have a combined length of 3 miles.

The total cost of the roads completed during the fiscal year was $3,418,864, of which the Federal share was $2,100,081. The actual disbursement of Federal funds to the State during the year was $1,728,033.

Complete statistics of the Federal-aid roads completed during the fiscal year and during the entire period under the Federal-aid plan with reference to mileage and types completed and the total costs and Federal-aid allotments are given in Tables 10 to 15, inclusive.

TABLE 10.—*Total cost, Federal aid and mileage of Federal-aid roads completed during the fiscal year 1925—by States*

States	Total cost [1]	Federal aid [1]	Miles [2]
Alabama	$8,946,220.40	$4,405,980.35	482.2
Arizona	1,685,978.33	999,603.78	132.8
Arkansas	4,713,282.21	1,766,874.26	188.0
California	7,378,440.12	3,945,529.15	265.5
Colorado	3,678,153.52	1,960,296.36	134.2
Connecticut	2,170,514.26	703,795.06	36.6
Delaware	1,169,291.33	465,084.42	31.4
Florida	3,328,705.13	1,627,053.47	100.2
Georgia	4,306,914.03	2,118,847.66	326.0
Idaho	1,287,097.12	771,198.81	113.1
Illinois	10,931,911.27	5,285,725.74	370.5
Indiana	8,312,508.53	4,027,473.09	266.8
Iowa	4,209,963.04	1,939,561.13	349.6
Kansas	8,265,215.10	3,593,498.16	337.0
Kentucky	4,159,571.09	1,662,848.80	145.7
Louisiana	4,538,345.13	2,195,489.99	324.1
Maine	1,330,368.99	641,229.37	51.0
Maryland	1,937,750.57	878,368.84	67.3
Massachusetts	4,280,919.94	1,474,830.91	74.5
Michigan	7,104,249.35	3,321,499.47	287.8
Minnesota	6,424,894.80	2,848,805.77	411.0
Mississippi	3,487,896.19	1,701,759.55	217.5
Missouri	9,808,732.34	4,780,496.96	443.5
Montana	1,462,935.43	1,024,548.18	132.0
Nebraska	2,656,656.84	1,276,615.35	155.8
Nevada	2,087,351.01	1,700,958.55	145.3
New Hampshire	1,147,421.31	531,483.77	38.8
New Jersey	4,802,169.82	1,158,534.72	70.4
New Mexico	5,008,465.60	3,340,291.69	473.4
New York	13,779,859.18	5,548,190.75	344.4
North Carolina	6,475,468.61	2,440,273.68	173.4
North Dakota	2,554,397.62	1,230,646.92	381.1
Ohio	8,899,524.96	3,548,113.26	240.8
Oklahoma	9,420,728.95	4,532,987.59	412.9
Oregon	2,618,037.60	1,510,345.67	153.0
Pennsylvania	8,605,471.97	2,436,027.93	156.6
Rhode Island	1,202,131.59	440,391.09	21.7
South Carolina	3,158,766.20	1,285,212.63	275.5
South Dakota	3,802,882.64	1,877,062.77	483.3
Tennessee	9,355,548.16	4,604,188.95	304.4
Texas	19,488,335.22	7,870,617.44	1,170.8
Utah	3,167,835.47	2,102,039.14	169.9
Vermont	1,112,697.48	519,943.89	33.6
Virginia	7,017,132.60	3,279,419.35	238.8
Washington	3,295,914.50	1,430,498.58	82.7
West Virginia	1,354,741.96	658,321.41	60.1
Wisconsin	3,586,726.64	1,742,090.95	127.8
Wyoming	3,418,864.42	2,100,081.88	325.5
Total	242,937,488.57	111,304,737.24	11,328.6

[1] Figures subject to revision on payment of a few final vouchers now outstanding.
[2] Mileage is of original improvement only.

TABLE 11.—*Total cost, Federal aid and mileage of Federal-aid roads completed to June 30, 1925—by States*

State	Total cost [1]	Federal aid [1]	Miles [2]
Alabama	$16,463,873.00	$8,051,693.34	1,153.7
Arizona	10,150,720.00	5,364,516.19	670.5
Arkansas	15,882,136.76	6,226,219.89	1,136.9
California	24,508,248.02	11,805,936.02	946.9
Colorado	13,302,271.86	6,835,486.02	712.5
Connecticut	5,582,139.35	2,137,293.66	118.4
Delaware	4,648,542.80	1,653,821.75	115.7
Florida	6,288,626.82	3,059,350.86	212.8
Georgia	22,562,665.58	10,604,649.07	1,652.8
Idaho	9,699,384.68	5,004,244.71	639.9
Illinois	41,460,938.34	19,345,542.33	1,284.7
Indiana	17,163,816.81	8,315,678.11	530.0
Iowa	27,602,428.68	11,262,792.99	2,038.2
Kansas	30,422,761.22	11,321,270.84	994.5
Kentucky	15,399,805.47	6,489,735.17	598.6
Louisiana	13,373,109.49	5,996,713.08	1,025.5
Maine	8,358,953.02	3,999,927.37	288.0
Maryland	8,939,352.66	4,211,045.90	320.0
Massachusetts	15,499,788.14	5,965,520.13	328.9
Michigan	22,755,690.19	10,488,793.25	861.7
Minnesota	30,415,685.89	12,738,642.04	2,721.2
Mississippi	11,376,090.08	5,530,604.87	872.5
Missouri	22,521,233.77	10,706,507.39	1,349.6
Montana	10,373,994.98	5,432,829.22	937.7
Nebraska	12,966,845.58	6,186,129.95	1,874.7
Nevada	6,034,574.22	4,025,094.73	427.8
New Hampshire	4,375,744.90	2,085,560.12	215.0
New Jersey	13,068,203.04	4,030,694.74	229.6
New Mexico	11,716,880.56	6,942,780.42	1,353.0
New York	35,294,569.79	14,834,806.53	972.0
North Carolina	23,303,899.06	9,685,395.85	1,178.5
North Dakota	11,731,991.01	5,695,294.02	2,015.3
Ohio	42,755,972.64	15,659,084.19	1,225.6
Oklahoma	22,407,594.21	10,421,839.62	910.2
Oregon	14,996,187.30	7,510,229.96	829.2
Pennsylvania	51,038,049.86	18,532,170.22	987.6
Rhode Island	3,154,691.99	1,282,219.05	70.8
South Carolina	12,437,758.75	5,600,823.54	1,311.1
South Dakota	13,274,837.18	6,580,479.99	1,579.9
Tennessee	16,934,117.22	8,304,567.87	596.5
Texas	61,999,406.37	24,113,040.85	4,332.3
Utah	7,348,884.53	4,505,616.11	487.4
Vermont	3,034,811.64	1,462,713.01	108.0
Virginia	18,312,886.55	8,669,620.37	859.6
Washington	14,488,392.67	6,662,211.87	551.9
West Virginia	7,526,593.06	3,321,662.43	335.9
Wisconsin	22,665,015.82	9,347,374.28	1,484.6
Wyoming	9,643,712.22	5,252,223.22	1,037.8
Total	845,263,877.78	373,260,447.14	46,485.5

[1] Figures subject to revision on payment of a few final vouchers now outstanding.
[2] Mileage is of original improvement only.

TABLE 12.—*Total program, as of June 30, 1925, of projects which have been approved for construction, completed, and under construction*

States	Total cost	Federal aid	Miles
Alabama	$21,721,117.65	$10,504,803.67	1,441.4
Arizona	12,045,158.35	6,533,086.25	804.8
Arkansas	21,111,304.41	8,912,138.43	1,479.7
California	32,781,771.52	15,765,110.57	1,161.5
Colorado	16,659,762.05	8,455,718.46	863.5
Connecticut	6,861,371.25	2,524,368.02	138.7
Delaware	5,653,541.71	2,042,606.50	138.3
Florida	11,863,044.76	5,776,197.57	348.2
Georgia	31,925,252.35	15,179,821.83	2,253.8
Idaho	12,263,216.79	6,610,751.77	792.1
Illinois	48,478,044.84	22,747,452.67	1,524.0
Indiana	29,340,487.73	14,176,644.83	878.2
Iowa	35,717,255.82	14,880,629.21	2,521.0
Kansas	39,625,020.47	15,268,992.44	1,444.5
Kentucky	23,721,026.27	10,226,092.83	923.9
Louisiana	15,881,666.62	7,189,935.33	1,100.4
Maine	9,325,488.71	4,451,897.75	323.5
Maryland	11,388,605.43	5,254,169.82	436.5
Massachusetts	20,148,478.42	7,080,748.62	395.7
Michigan	31,203,535.13	14,404,492.15	1,088.1
Minnesota	39,922,009.95	16,803,842.04	3,551.5
Mississippi	19,941,448.61	9,805,981.89	1,336.3
Missouri	45,255,850.19	19,874,012.47	2,006.5
Montana	13,257,681.89	7,421,424.00	1,221.5
Nebraska	19,063,120.18	9,132,941.21	2,462.7
Nevada	10,114,637.99	7,488,989.87	824.1
New Hampshire	5,284,963.53	2,511,945.92	243.2
New Jersey	22,505,602.63	7,405,569.89	301.9
New Mexico	13,276,986.48	7,927,932.02	1,488.0
New York	65,318,395.54	24,342,800.58	1,577.5
North Carolina	30,687,729.95	12,938,570.65	1,380.5
North Dakota	14,921,438.07	7,337,458.78	2,479.9
Ohio	54,372,726.35	19,963,786.33	1,576.2
Oklahoma	28,680,690.70	13,427,421.09	1,210.8
Oregon	18,015,424.29	9,254,742.91	970.4
Pennsylvania	81,009,259.40	26,435,248.03	1,534.7
Rhode Island	5,088,995.54	1,773,727.68	100.1
South Carolina	18,580,840.57	8,414,936.56	1,644.3
South Dakota	20,039,774.14	9,912,403.86	2,513.9
Tennessee	26,153,419.06	12,319,834.21	920.6
Texas	81,938,512.37	32,528,591.55	5,601.5
Utah	9,465,524.65	6,020,365.11	674.5
Vermont	4,661,616.12	2,182,635.92	143.3
Virginia	24,932,017.80	11,592,157.51	1,083.6
Washington	17,201,171.04	7,905,111.87	676.3
West Virginia	14,604,159.47	6,163,017.64	525.8
Wisconsin	27,149,828.51	11,543,732.98	1,722.4
Wyoming	13,171,039.06	7,484,820.46	1,293.4
Hawaii	342,277.22	97,440.00	6.5
Total	1,182,672,291.58	517,997,101.75	61,129.7

TABLE 13.—*Mileage of Federal-aid roads completed during the fiscal year 1925, by types of construction*

State	Graded and drained	Sand-clay, etc.	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land cement con-crete	Brick	Bridges	Total
Alabama		29.2	373.4		46.8	31.9			0.9	482.2
Arizona	87.1		29.9			7.5	7.1		1.0	132.8
Arkansas		3.1	67.3	−4.5	31.6	67.0	23.2		.2	188.0
California	33.7		107.1	10.8	9.9	23.1	80.0		.8	265.5
Colorado	20.9	8.4	55.8				47.7		1.5	134.2
Connecticut				8.8			27.9			36.6
Delaware							31.2		.2	31.4
Florida	20.0	12.9			22.7	4.2	40.1		.2	100.2
Georgia	15.3	218.6	76.3	5.2	[1] −.7		6.5	.2	4.4	326.0
Idaho	47.2	.2	65.3						.2	113.1
Illinois	3.0						366.1	1.3	.2	370.5
Indiana	19.3		14.7	7.5	17.0		207.0		1.2	266.8
Iowa	237.2		45.0				67.1		.2	349.6
Kansas	84.5	71.2	15.4		28.0		126.3	10.0	1.7	337.0
Kentucky	91.2		27.4	2.7	23.8				.6	145.7
Louisiana			313.2		9.5				1.6	324.4
Maine			19.1		31.9					51.0
Maryland			2.6		14.3		50.3			67.3
Massachusetts					43.4	5.2	25.1		.8	74.5
Michigan	25.7		95.0		5.0	14.6	147.5	.4		287.8
Minnesota	245.1		114.8				51.1		.1	411.0
Mississippi	60.3	3.2	125.6		1.0	5.8	21.4		.2	217.5
Missouri	98.0		189.1	5.2	10.0	14.9	124.4	.5	1.5	443.5
Montana	22.6		109.0						.3	132.0
Nebraska	133.3	[1] −21.6	35.6			2.7	2.7	2.4	.9	155.8
Nevada	3.6	17.9	112.1		5.0		5.8		.9	145.3
New Hampshire			8.2	8.9	16.9	2.3	2.4		.1	38.8
New Jersey	1.6					7.6	61.1		.1	70.4
New Mexico	30.2		427.0				16.1			473.4
New York					50.4	4.8	289.2			344.4
North Carolina	9.8	[1] −7.6		[1] −5.0	5.0	48.1	122.9		.2	173.4
North Dakota	325.8		54.7			.5			.2	381.1
Ohio	9.2				41.5	3.4	101.3	85.3		240.8
Oklahoma	12.1		247.1			19.5	128.6	2.8	2.7	412.9
Oregon	13.6		120.1				18.9		.4	153.0
Pennsylvania						2.2	154.0	.4		156.6
Rhode Island						5.5	16.2			21.7
South Carolina	10.8	230.2	6.9			15.9	10.4		1.4	275.5
South Dakota	86.1	2.5	394.4						.4	483.3
Tennessee	9.8		33.1	1.7	216.3	14.5	28.9		.1	304.4
Texas	135.0	3.1	565.9	85.9	198.1	27.9	133.4	4.0	17.7	1,170.8
Utah	[1] −13.8	37.6	110.2				35.0		.8	169.9
Vermont			21.5	2.0	1.8		7.3		1.0	33.6
Virginia	9.0	20.7	13.6		80.2	7.3	107.3		.6	238.8
Washington	24.3		34.5				23.5		.4	82.7
West Virginia	32.4		.1		2.6	4.9	20.2			60.1
Wisconsin			58.1				69.8			127.8
Wyoming	120.2	89.2	113.7				1.4		1.0	325.5
Total	2,064.1	718.8	4,202.9	129.2	911.9	341.3	2,806.4	107.3	46.7	11,328.6

[1] Negative figures caused by revision of records when final vouchers were paid on projects the type of which was changed after ratification of project agreement.

TABLE 14.—*Mileage of Federal-aid roads completed to June 30, 1925, by types of construction*

State	Graded and drained	Sand-clay, etc.	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land cement con-crete	Brick	Bridges	Total
Alabama	3.2	315.9	651.1	11.6	73.4	86.7	9.6		2.2	1,153.7
Arizona	139.8	55.9	342.5	14.2		16.5	99.4		2.2	670.5
Arkansas		3.1	727.3	40.3	61.1	243.4	60.4		1.3	1,136.9
California	252.5		209.8	18.1	55.5	49.6	359.6		1.8	946.9
Colorado	171.4	75.8	296.6			1.0	164.0		3.7	712.5
Connecticut				8.8	27.0		82.6			118.4
Delaware							109.3	6.2	.2	115.7
Florida	20.0	34.1			64.8	12.8	70.7	10.1	.3	212.8
Georgia	73.6	1,055.5	286.2	27.4	69.1	11.6	109.9	.5	19.0	1,652.8
Idaho	158.6	18.8	402.8	4.3		33.0	21.3		1.1	639.9
Illinois	138.1		.4		3.3	8.1	1,114.8	18.6	1.4	1,284.7
Indiana	19.8		27.1	7.5	17.0	12.0	445.0		1.6	530.0
Iowa	1,251.6		389.4				375.0	22.0	.2	2,038.2
Kansas	181.6	88.0	125.2	4.5	56.5		431.4	105.6	1.7	994.5
Kentucky	335.8		69.2	41.1	105.8		42.0	3.9	.8	598.6
Louisiana	7.4		996.2	3.2	9.5	7.6			1.6	1,025.5
Maine			120.5		128.0		39.3		.2	288.0
Maryland	3.8		31.5	.1	41.6	12.3	230.7			320.0
Massachusetts				3.3	184.4	30.2	109.7		1.3	328.9
Michigan	25.7		319.8	18.9	5.0	76.1	415.8	.4		861.7
Minnesota	466.1		1,970.7			22.1	261.9		.4	2,721.2
Mississippi	181.7	17.6	569.1	11.1	1.0	9.2	73.4	9.2	.2	872.5
Missouri	300.1		708.0	13.4	48.9	17.7	252.3	6.2	3.0	1,349.6
Montana	215.8		664.9	16.0	6.9	.9	31.3		1.9	937.7
Nebraska	1,454.1	141.5	217.1			9.4	37.4	14.3	.9	1,874.7
Nevada	73.5	24.9	265.4		20.6	1.6	40.4		1.4	427.8
New Hampshire			94.8	32.0	52.8	30.0	4.3		1.1	215.0
New Jersey	1.6		3.4			12.6	211.9		.1	229.6
New Mexico	221.8	5.1	1,065.3			.7	59.3		.8	1,353.0
New York					267.9	4.8	697.1	.7	1.5	972.0
North Carolina	76.1	590.4	85.8	12.8	38.0	141.5	232.3		1.6	1,178.5
North Dakota	1,648.0	6.5	355.0			1.2	3.0		1.6	2,015.3
Ohio	34.2			82.6	246.3	88.1	393.4	380.9	.1	1,225.6
Oklahoma	40.4	2.3	526.7	6.3	.6	64.5	257.5	4.0	7.9	910.2
Oregon	110.2		553.7	25.6		52.9	85.7		1.1	829.2
Pennsylvania					7.8	101.9	852.7	25.2		987.6
Rhode Island					10.5	37.0	23.3			70.8
South Carolina	10.8	1,105.4	100.9		3.0	38.0	49.0	.2	3.8	1,311.1
South Dakota	281.7	2.5	1,293.8				.8		1.1	1,579.9
Tennessee	13.1		94.4	52.3	363.4	21.9	50.8		.6	596.5
Texas	303.8	61.2	2,756.2	448.0	309.3	77.7	329.5	24.8	21.8	4,332.3
Utah	101.1	37.6	242.3	9.3		7.8	88.0		1.3	487.4
Vermont			72.8	3.4	19.7		10.8		1.3	108.0
Virginia	27.0	199.7	84.7	108.5	186.2	10.6	241.6		1.3	859.6
Washington	52.4		296.8				200.9		1.8	551.9
West Virginia	138.5	1.7	18.3	4.9	69.7	16.3	74.9	11.4	.2	335.9
Wisconsin	233.6	140.5	731.9	2.7	9.6		366.3		.1	1,484.6
Wyoming	310.8	462.3	246.2			1.2	14.3		3.0	1,037.8
Total	9,079.2	4,446.3	18,013.8	1,032.2	2,564.2	1,370.5	9,234.6	644.2	100.5	46,485.5

TABLE 15.—*Mileage of total Federal-aid program as of June 30, 1925, by types of construction*

States	Graded and drained	Sand-clay, etc.	Gravel	Water-bound macad-am	Bitu-minous macad-am	Bitu-minous cement con-crete	Port-land cement concrete	Brick	Bridges	Total
Alabama	53.1	366.2	795.6	11.6	73.4	86.7	51.1	-------	3.7	1,441.4
Arizona	168.7	93.1	395.3	14.2	-------	22.7	108.6	-------	2.2	804.8
Arkansas	-------	3.1	939.2	70.8	109.7	250.4	104.4	-------	2.1	1,479.7
California	319.4	-------	283.1	18.1	62.1	62.2	413.9	-------	2.6	1,161.5
Colorado	200.7	75.8	386.8	-------	-------	1.0	195.6	-------	3.7	863.5
Connecticut	-------	-------	-------	8.8	27.0	-------	102.8	-------	-------	138.7
Delaware	-------	-------	-------	-------	-------	-------	131.9	6.2	.2	138.3
Florida	46.5	34.1	-------	36.5	72.6	41.8	97.7	10.1	8.9	348.2
Georgia	154.0	1,385.3	373.5	59.3	105.5	14.5	137.2	.5	23.9	2,253.8
Idaho	176.7	18.8	516.3	4.3	-------	42.3	32.8	-------	1.1	792.1
Illinois	138.1	-------	.4	-------	3.3	8.1	1,354.0	18.6	1.5	1,524.0
Indiana	25.7	-------	32.1	46.5	17.0	12.0	730.9	11.0	3.0	878.2
Iowa	1,528.9	-------	441.8	-------	-------	-------	527.8	22.0	.4	2,521.0
Kansas	421.2	105.4	199.6	4.5	125.7	.4	459.9	125.0	2.8	1,444.5
Kentucky	559.4	-------	76.8	51.5	138.2	-------	93.2	3.9	.8	923.9
Louisiana	29.2	-------	1,040.9	3.2	9.5	10.4	3.6	-------	3.6	1,100.4
Maine	-------	-------	135.8	-------	142.0	5.3	39.3	-------	1.3	323.5
Maryland	3.8	-------	31.5	.1	41.6	12.3	347.2	-------	-------	436.5
Massachusetts	-------	-------	-------	3.3	207.2	30.2	153.2	-------	1.8	395.7
Michigan	30.5	-------	329.9	18.9	10.4	76.1	621.9	.4	-------	1,088.1
Minnesota	966.5	-------	2,264.6	-------	-------	22.1	297.8	-------	.6	3,551.5
Mississippi	245.5	17.6	887.4	11.1	1.0	19.1	144.8	9.2	.7	1,336.3
Missouri	468.0	-------	819.6	13.4	60.2	17.7	597.3	21.0	9.3	2,006.5
Montana	252.6	-------	911.5	16.0	6.9	.9	31.3	-------	2.3	1,221.5
Nebraska	1,718.7	211.9	465.9	-------	-------	10.1	37.4	14.3	4.3	2,462.7
Nevada	83.6	24.9	645.2	-------	20.6	1.6	45.6	-------	2.6	824.1
New Hampshire	-------	-------	98.6	40.3	64.1	31.9	5.2	-------	3.1	243.2
New Jersey	3.5	.8	3.4	-------	-------	12.6	280.2	-------	1.5	301.9
New Mexico	228.5	5.1	1,183.5	-------	-------	.7	69.3	-------	.8	1,488.0
New York	6.7	-------	54.4	-------	356.7	11.8	1,145.7	.7	1.5	1,577.5
North Carolina	127.1	590.4	85.8	12.8	42.7	190.4	329.1	-------	2.1	1,380.5
North Dakota	2,050.7	6.5	416.3	-------	-------	1.2	3.0	-------	2.4	2,479.9
Ohio	67.2	-------	-------	104.9	339.4	93.8	533.1	437.8	.2	1,576.2
Oklahoma	137.4	2.3	607.0	6.3	.6	72.4	371.7	4.0	9.1	1,210.8
Oregon	166.1	-------	631.5	25.6	-------	52.9	92.3	-------	2.0	970.4
Pennsylvania	65.3	-------	-------	-------	7.8	101.9	1,334.5	25.2	-------	1,534.7
Rhode Island	-------	-------	-------	-------	16.2	38.3	45.5	-------	-------	100.1
South Carolina	22.4	1,349.9	146.1	-------	3.0	48.2	66.2	.2	8.2	1,644.3
South Dakota	821.2	2.5	1,686.5	-------	-------	-------	.8	-------	2.8	2,513.9
Tennessee	177.1	-------	106.3	52.3	421.0	21.9	140.5	-------	1.5	920.6
Texas	734.7	73.6	3,162.5	516.3	485.7	97.7	479.0	29.2	22.7	5,601.5
Utah	101.1	37.6	424.7	9.3	-------	7.8	92.1	-------	1.8	674.5
Vermont	-------	-------	88.1	3.4	31.7	-------	17.8	-------	2.5	143.3
Virginia	62.6	202.7	116.5	114.3	261.4	10.6	314.1	-------	1.6	1,083.6
Washington	121.7	-------	320.4	-------	-------	-------	232.2	-------	2.1	676.3
West Virginia	199.7	5.6	27.0	7.9	109.2	40.8	123.8	11.4	.5	525.8
Wisconsin	242.9	140.5	887.5	2.7	13.8	-------	434.9	-------	.1	1,722.4
Wyoming	478.8	470.8	320.2	-------	-------	1.2	18.4	-------	4.0	1,293.4
Hawaii	-------	-------	-------	-------	-------	6.5	-------	-------	-------	6.5
Total	13,405.4	5,224.6	22,339.3	1,288.1	3,387.2	1,590.4	12,990.6	750.7	153.9	61,129.7

TRANSCONTINENTAL HIGHWAYS DESIGNATED

As the result of the general improvement in the condition of roads throughout the country and the greatly increased use of motor vehicles the range of travel by highways has been so extended that transcontinental journeys are by no means uncommon. In consequence of this development the early improvement of a limited number of transcontinental routes and the uniform marking of such roads by all States has become one of the most pressing needs.

The State highway departments, recognizing their responsibility in this respect and believing the matter to be one requiring joint action by the several State highway departments and the Federal Government, the American Association of State Highway Officials recommended that the Secretary of Agriculture appoint a joint board of Federal and State officials to designate the transcontinental routes and decide on a uniform

marking system. In response to this recommendation the Secretary appointed the joint board on interstate highways in February, 1925, selecting as members 24 representative Federal and State highway officials.

At the first meeting of the board in Washington on April 20, a series of cautionary, directional, and informational signs was tentatively decided upon subject to approval by the several State highway departments to which they were submitted in a number of regional meetings. At these regional meetings members of the board also received from the State highway departments their recommendations with regard to the routes to be designated. These recommendations were considered and harmonized at a second meeting of the board held in Washington on August 3, as the outcome of which a definite system of transcontinental roads was designated and standard signs for use by all States on the designated system were adopted.

The transcontinental routes designated are all included in the Federal-aid highway system. Their designation and adoption by all States is an accomplishment of the highest order, carried out in a splendid spirit of cooperation by the Federal and State departments. Its immediate effect should be to facilitate compliance with section 6 of the Federal highway act which requires that the Secretary of Agriculture shall give preference in approving projects to those which will expedite the completion of an adequate and connected system of highways interstate in character.

Preferential consideration given to the improvement of the designated transcontinental system should at a very early date result in the complete improvement of the system, and the uniform numbering and signing of the system in all States will be of inestimable value in promoting the safety and convenience of the highways used by interstate traffic.

FOREST-HIGHWAY IMPROVEMENT

The forest-highway systems have been definitely selected and approved by the Secretary of Agriculture in all States except Oregon and New Mexico, and all funds available for forest-highway improvement are being expended only on the approved systems. In Oregon and New Mexico, approval of projects is being limited to the systems recommended by the Bureau of Public Roads pending final agreement of the cooperating agencies on systems which can be approved by the Secretary.

The total mileage of the approved systems, including the mileage in the recommended Oregon and New Mexico systems, is 13,396 miles. Of this total, 1,043 miles are class 1 highways, i. e., roads which are necesary sections or extensions of the Federal-aid system wholly within the national forests. Class 2 roads, which are extensions of the Federal-aid system and partly within or adjacent to and serving the national forests, have a total length of 6,904 miles: and class 3 roads, which are roads of primary importance to counties or communities within the forests, have a total length of 5,449 miles. Of the total mileage selected, 4,011 miles or approximately 30 per cent are necessary sections of the Federal-aid highway system.

In the forest-highway work as in the Federal-aid road work the progress made during the last fiscal year was very gratifying. The initial improvement of 603 miles and the betterment of 78 miles previously improved is a year's record which has not been exceeded in any previous year except 1921, when 729 miles were added.

Of the 681 miles improved initially or by betterment of type during the year, 635 miles were in 12 States of the far West and the Territory of Alaska, the balance of 46 miles being located in the States of Arkansas, Florida, Georgia, and Tennessee. The total cost of the completed roads was $8,658,516, of which $8,470,516 was expended in the Western States and Alaska.

The total mileage of forest roads improved by the Bureau of Public Roads up to the close of the fiscal year was 2,429 miles. The mileage and cost of the roads completed in each State during the fiscal year are given in Table 16.

TABLE 16.—*Forest highways completed during the fiscal year 1925*

State	Mileage completed	Total cost	Remarks
	Miles		
Alaska	29.5	$527,947.96	Includes 3.6 miles of surfacing only.
Arizona	62.1	435,908.18	Includes 23.4 miles on which only drainage structures were added.
California	40.4	823,886.69	Includes 10.9 miles of surfacing only.
Colorado	35.8	588,376.39	
Idaho	107.4	1,647,953.24	Includes 7 miles of clearing only.
Montana	51.5	685,051.55	Includes 7.1 miles of clearing only.
Nevada	58.9	401,723.94	
New Mexico	11.5	163,001.11	
Oregon	114.2	1,847,121.43	
South Dakota	8.5	108,416.04	
Utah	53.0	320,043.12	Includes 6.3 miles widened and 20 miles improved.
Washington	24.2	557,567.36	
Wyoming	38.5	363,519.15	
Arkansas	10.8	95,499.34	
Florida	28.6	82,134.47	
Georgia	.1	10,365.85	Bridge.
Tennessee	6.5	10,366.85	
Total	681.5	8,668,882.67	

In addition to the mileage of forest roads completed there was under construction at the close of the fiscal year 931.87 miles, including 135.87 miles of roads previously constructed as earth roads and now being surfaced. It is estimated that this work will cost more than $12,000,000. The disbursements up to the close of the year were $8,256,012.

The forest roads constructed under the supervision of this bureau are those which are of primary importance to the States and to counties and communities located within and adjacent to the forest areas. Forest-development roads and trails are constructed mainly under the supervision of the Forest Service.

Because of the large extent of the forest reservations in the Western States, and especially by reason of the fact that their location follows approximately the mountain ranges, so that they include the important mountain passes, no interstate highway system can be complete which does not include connections across the forest areas.

Such connections, imperatively required from the economic standpoint, also serve to make accessible to the increasing army of motor tourists the scenic beauties in which the forests abound. Moreover, as the national parks are practically surrounded by forests, in almost every case approach to the parks by motorists is dependent upon the construction of the main roads through the forests.

It is especially desirable, therefore, that the activities of the State highway departments and those of this bureau, the Forest Service, and the National Park Service shall be closely correlated. The highway work of each of these agencies should be so correlated that continuous routes leading to and through the national parks and forests shall be built as speedily as possible, leaving the lesser routes for later development.

In view of the desirability of such a correlation of effort it is gratifying to report that an arrangement has been perfected during the past year under which the Bureau of Public Roads will cooperate with the National Park Service by making surveys, plans, and estimates for roads to be constructed in the national parks and by superintending the construction of major projects. The bureau will also be consulted in a general way on all national-park road work.

The transmountain highway in Glacier National Park, Mont., has already been let to contract under this arrangement. This project, which is one of the most important, is a part of one of the transcontinental highways. It lies between Lake McDonald and St. Mary Lake and connects the two via Logan Pass. In making the survey for the project every effort was made to preserve and make accessible the scenic features of the park as well as to provide a safe and comparatively light grade for the highway.

In addition to the transmountain highway surveys have been made in the Grand Canyon National Park, Hawaii National Park, and Rainier National Park, and others are under way in the Rocky Mountain, Sequoia, Yosemite, Yellowstone, Zion, and other parks.

SURPLUS WAR MATERIALS

Except the explosives, of which there is still a supply to be distributed, the distribution of war materials declared surplus by the War Department is now practically completed. Since the fiscal year 1920, when the distribution was begun, materials of an estimated value of more than $247,000,000 have been distributed to State highway departments, other branches of the Federal establishment, and to farmers.

The materials shipped to State highway departments have been supplied for use in highway construction, and the aid extended in this way has been in many ways as helpful as the monetary aid. The value of the material received by the States up to the close of the fiscal year was more than $215,000,000. Materials transferred to branches of the Federal Government other than the Bureau of Public Roads are valued at more than $18,500,000 and the explosives distributed to farmers for use in land clearing and other agricultural operations are valued at more than $5,600,000.

The estimated total value of all material delivered to consignees up to the close of the fiscal year is given in Table 17.

TABLE 17.—*Estimated total value of all surplus war material delivered up to the end of the fiscal year 1925*

Consignee	Estimated value
U. S. departments and establishments:	
Department of Agriculture—	
Bureau of Public Roads	$7,792,732.30
Other bureaus	2,278,157.64
War Department	9,823,358.09
National cemeteries	615.00
Navy Department	57,838.00
Marine Corps	168,411.70
Post Office Department	939,160.00
Treasury Department, Public Health Service	19,225.34
Interior Department—	
Indian Service	111,979.50
National Park Service	318,848.25
Reclamation Service	89,140.00
St. Elizabeths Hospital	46,723.00
Alaska Railroad	9,225.00
Miscellaneous	9,029.00
Department of Justice	175,000.00
Veterans' Bureau	3,808,941.00
Board of Road Commissioners for Alaska	86,727.84
The Panama Canal	155,060.59
U. S. Soldiers' Home	18,339.90
U. S. Shipping Board	62.88
U. S. Housing Corporation	4,730.00
Government Printing Office	2,150.00
District of Columbia	575,188.28
Total to U. S. departments and establishments	26,490,643.31
Farmers, for land clearing	5,662,884.10
Total to U. S. departments, etc., and farmers	32,153,527.41
States, for road building:	
Alabama	3,063,797.01
Arizona	4,021,944.60
Arkansas	2,875,257.56
California	7,365,573.81
Colorado	4,378,788.64
Connecticut	1,003,206.38
Delaware	495,684.70
Florida	5,015,226.87
States, for road building—Contd.	
Georgia	$7,219,278.27
Idaho	2,157,856.72
Illinois	8,174,245.20
Indiana	8,398,286.59
Iowa	7,633,605.99
Kansas	5,411,802.69
Kentucky	3,908,613.33
Louisiana	3,365,830.68
Maine	1,800,026.44
Maryland	2,431,855.22
Massachusetts	2,115,668.47
Michigan	9,868,032.09
Minnesota	4,527,332.15
Mississippi	3,183,592.46
Missouri	5,688,797.22
Montana	3,018,929.95
Nebraska	3,297,288.49
Nevada	1,800,117.20
New Hampshire	984,711.98
New Jersey	2,948,515.46
New Mexico	3,899,666.90
New York	11,345,425.61
North Carolina	6,966,295.77
North Dakota	2,331,000.98
Ohio	7,092,805.69
Oklahoma	3,801,188.01
Oregon	3,703,599.98
Pennsylvania	5,996,746.56
Rhode Island	655,788.25
South Carolina	4,703,811.62
South Dakota	4,139,630.94
Tennessee	6,102,441.21
Texas	11,227,259.99
Utah	1,940,129.00
Vermont	789,402.25
Virginia	7,529,778.87
Washington	4,012,889.46
West Virginia	5,729,278.72
Wisconsin	4,734,276.34
Wyoming	2,169,752.77
Total to States for road building	215,025,035.09
Grand total	247,178,562.50

RESEARCH AS AN AID TO ADMINISTRATION

The building of a national highway transportation system is a trust which the bureau feels can not be faithfully administered without constant effort to broaden the field of scientific knowledge of the materials and processes employed in the construction. The highway researches of a physical and economic character in which it has been engaged for a number of years are regarded, therefore as a highly important department of the work.

During the past year the most significant results have been obtained in three branches of this work. A field study and careful analysis of the elements affecting the cost of grading and concrete paving have led to the development of managerial methods the application of which in test projects has cut costs of construction virtually in half. No more practical or immediately beneficial study has ever been made by the bureau. The second result of importance has been the development of methods of analyzing the flow of traffic over a highway system and the application of the results of such analysis to the economic improvement of the system. These methods applied in California, Maine, Connecticut, Pennsylvania, Ohio, and Cook County, Ill., have been instantly recognized by the State and local officials as a most valuable aid to administration. The third outstanding advance is that which has rewarded the prolonged study of highway subgrades. Practical methods have been devised for the identification of suitable soils, and there is reasonable ground for hope that corrective treatments will soon be developed that will make it possible to overcome the handicap of unsuitable soils.

In the analysis of construction costs the first work was a study of the operation of earth-moving equipment. Beginning with the lighter equipment, such as slip scrapers, wheelers, and fresnoes, the investigations were later extended to include the operation of elevating graders, steam shovels, drag lines, and dredges. Each type of equipment has been studied in operation with the object of determining the extent of the preventable time losses. Such losses have been detected even on well-managed projects, their presence wholly unsuspected by the contractor because of the lack of a detailed study of the operations involved in the work. Once detected it is a comparatively simple matter to eliminate them by careful management; and the tests made indicate that savings of from 25 to 35 per cent of the earth-moving cost may generally be made on average projects.

The concrete-paving studies have had a similar purpose, i. e., to develop precisely the reasons why production so commonly fails to reach rates theoretically attainable. The observations made have clearly established these reasons, and the bureau has induced a number of contractors to make the changes in operating methods shown to be necessary with the most striking results.

In one case production under the contractor's management had averaged 36 lineal feet of pavement an hour and about 180 feet a day. As a result of suggestions made by the bureau's engineers production rose steadily during the test period of about a month to an average of 62.5 feet an hour attained during the last nine days and the daily production increased even more sharply as a result of the elimination of heavy time losses which had the effect of increasing the length of the working day. The effect of this improvement was to reduce the labor cost from $0.457 per square yard, which had been the average cost to the contractor, to $0.203 per square yard.

On another project the contractor's production had averaged 64 feet an hour and 486 feet a day. The suggestions made by the bureau's representative raised the output to a 7-day average of 97 feet an hour and a maximum of 101 feet for 12½ hours, a day's run of 1,263 feet. In this case labor had cost the contractor $0.207 per square yard of pavement laid as against a cost of $0.128 per square yard for the last week of the test period. Under the contractor's management 35,743 square yards were laid in slightly over two months, while during the last week of the test period 10,096 square yards were laid, and this in spite of the fact that of the six working days, one-half day was lost on account of rain and another half day at the end of the period by the completion of the pavement to be laid at noon of the last day.

PHYSICAL RESEARCHES AND TESTS

These investigations, in general, cover researches the aim of which is to establish facts which will lead to more durable and economical pavement design, more economical use of road materials and better combinations more suitable for present day heavy motor-truck traffic, and finally, to obtain data which will serve as the basis for legislation pertaining to motor vehicles in their relation to the highways.

Subgrade materials.—The work on subgrade materials is one of the major research projects. This work is subdivided under several headings, which include bearing value, determination of physical characterstics of subgrade materials, the effect of moisture, and the effect of alternate freezing and thawing; also field investigations to determine what method of treatment is necessary to properly prepare and improve a subgrade preparatory to building the road surface. A tentative classification of subgrade material has resulted which aids in interpreting and predicting subgrade conditions. This classification requires the determination of several physical characteristics, the tests necessary for which have been further revised and developed. The methods of examination, testing and treatment of subgrade materials and subgrades, while very greatly advanced, are not fully satisfactory in their practical application, and the main effort during the past year, which effort is to be extended, has been to develop simple and practical methods. A general subgrade map of the United States has been prepared.

Measurements of stresses under actual road conditions.—This subject includes the determination of actual stresses and deflections of concrete roads of different designs and of specially constructed roads under the influence of actual traffic. As a result of the investigation the distribution of stresses in road slabs under heavy traffic has been discovered and this investigation in connection with others already conducted has resulted in a more rational method for the design of concrete road surfaces. These researches on road design have undoubtedly had very great influence in producing much more durable and economical pavements throughout the country than have been built in the past, and millions of dollars were saved in the past year alone through the use of designs thus established. Thirty-three of the States have now adopted the design which these investigations and others have brought about.

Bridge design.—A series of tests to determine the action and strength of skew arches has just been finished. These studies have been conducted over a period of two years. Some very definite and positive results have been obtained showing the distribution of the load reactions and thrust on skew arches, which are of vital interest to engineers engaged in bridge design.

Measurement of impact of motor trucks.—This project has been conducted in cooperation with The Rubber Association of America and the Society of Automotive Engineers over a period of about two years. Its purpose is to determine the destructive effect of motor trucks on road surfaces. The impact of motor trucks has been determined under a variety of conditions of load, speed, type of truck, tire equipment, and character of road surface, and the results of the tests have made it possible to predict the relative effect of motor trucks on roads under the several conditions.

Nonbituminous road materials.—Miscellaneous small tests have been conducted to establish particular facts in conection with the use of materials from certain sources of supply. As the result of these special tests, materials have been made available for use which previously had been thought to be unsuitable. Additional work has been done during the past year in devising an abrasion test for concrete sands which will indicate the quality of the grains. A number of samples of sand have been subjected to a special abrasion test using the Deval abrasion cylinder, and preliminary conclusions indicate that the test gives, in general, a good idea of the durability of the grains.

A considerable amount of work has been done on the question of size and shape of screen openings for sieving. This is a matter which is involved in specifications for materials and which has caused considerable trouble in the past.

A new device has been constructed, after investigation, which satisfactorily measures the consistency of concrete in the field as well as in the laboratory. In view of the established fact that the proper consistency is the chief factor in controlling the strength of concrete, the importance of this development can not be overemphasized. Its use should make pos-

sible the construction of concrete structures of considerably higher strength and greater durability than those built in the past.

Apparatus has also been devised for measuring the pressure in molding cement briquettes, which will make for greater uniformity in testing and correspondingly less contention in regard to the acceptance of cement based on tests. Tests have also been conducted looking toward the determination of the effect of quality of cement on the compressive strength of Portland-cement concrete. An extensive series of tests has been run on high-alumina cement, which recently has been used extensively for special work in connection with highways and bridges. These tests aid in establishing the limitations of the cement, the conditions under which it should be used, and the way it should be handled.

A series of investigations to determine the cause of scaling of concrete roads has also been finished. Five hundred and twenty-six specimens of concrete were subjected to freezing and thawing, and the various factors thought to be productive of scaling were investigated. Many of the specimens scaled or completely disintegrated in from 40 to 140 alterations of freezing and thawing.

Bituminous road materials.—A second series of 33 experimental test sections was constructed on the circular roadway at the Arlington Experimental Farm during July, 1924, comprising among others five pavements employing as many different sand mixtures. The latter were designed for the particular study of variations in proportions of the mixture. After the installation of devices for the measurement of temperatures and movement of the pavement, traffic was operated from August to November, using a loaded 5-ton motor truck. The effect of traffic was observed almost immediately on certain sections, diminishing as the weather became cooler. Traffic was resumed in the spring and is now demonstrating decided differences in behavior between a number of the sections.

Closely related to the latter investigation is the one involving laboratory tests of the same mixtures used in the circular track tests. These tests furnish a means of correlating service behavior with laboratory determinations of relative stability for the many possible combinations of materials. The first phase of the laboratory investigations is the development of a test or tests for differentiating between mixtures of known behavior under traffic and evaluating their relative resistance to displacement. The laboratory has concentrated on this problem during the past year and has developed, first, a method of forming the test specimens and, second, a test by which the resistance of the specimens to deformation in a confining mold is measured. The testing procedure was recently described in a paper delivered before the American Society for Testing Materials. Results obtained during the development of the test are very promising, and a continuation of the study will furnish an increasing fund of data to be used in the determination of those proportions and characteristics of the asphalt, sand, and dust which will prevent or limit the waving of asphalt pavements under heavy traffic.

The work of standardizing bituminous materials and methods of testing is carried on largely in cooperation with technical committees of Government and national organizations. Assisting in the work of the Federal Specifications Board, the bureau has taken part in compiling a series of specifications for bituminous and nonbituminous road materials. Those for the most important bituminous materials have been adopted by the board, and those for nonbituminous materials are now in the final stages of their preparation. The bureau has also assisted in the work of the technical committee on liquid fuels and lubricants. In connection with the work of the American Society for Testing Materials, in addition to general participation in the discussions of committees, laboratory work has been accomplished on extensive studies of tests for the asphaltic content of road oils and the distillation of tars or similar products.

Field experiments.—Field experiments have been conducted with the object of improving the service value of the low-type roads such as earth, sand-clay, top soil, and gravel. In Iowa and South Dakota short experimental sections of earth road have been constructed with admixtures of hydrated lime and Portland cement, with the idea of stabilizing the soil and rendering it less muddy in wet weather. In South Carolina two experimental sections have been constructed involving the surface treatment of top-soil roads in different ways and with different kinds of bituminous materials. Preliminary work has also been begun on a special experiment on the Mount

Vernon-Gum Spring Road in Virginia, which will later be given special treatments in further development of this type of surfacing for automobile and motor-bus traffic.

Cooperative investigations.—The cooperative researches with a number of institutions were continued during the past year, involving investigations of road materials, subgrade materials, design, and economics. The agencies engaged in cooperative work with the bureau and the general subjects of their investigations are as follows:

Purdue University: Investigations on highway concrete.

Iowa State College: Tractive resistance of motor vehicles, highway-bridge impact, loads on highway culverts, and effect of pavement characteristics on fuel consumption.

University of Georgia: Sand-clay and topsoil road investigations.

Kansas State College: Wind-resistance investigations.

University of Kansas: Tire wear as affected by the type of road.

Pennsylvania State Highway Department: Guard-rail investigations and special investigations of concrete highway design.

Ohio State University: Field and laboratory investigations of subgrades.

Johns Hopkins University: Physical investigations of concrete under impact.

Cooperation was also given to the Delaware River Bridge Joint Commission in connection with the floor system and pavement of the new Delaware River suspension bridge between Philadelphia and Camden.

Testing highway materials.—Routine examinations of both bituminous and nonbituminous road materials is one of the important functions of the bureau laboratories. These examinations are made primarily on materials used in Federal-aid road construction or in the construction of forest roads. Results of tests on such materials are sent to a large number of laboratories performing tests on Federal-aid samples in order that these laboratories may have a check on their results against those obtained by the bureau. Cooperative tests were conducted with approximately 50 of the road materials testing laboratories of the country, and a number of tests were made in cooperation with laboratories at their special request in order to check their personnel and equipment. Instruction in materials testing was given to personnel from four of the district offices.

ECONOMIC RESEARCHES

The purposes of the bureau's highway economic research are to obtain the facts and determine the principles which must be the basis of the planning and construction of the highway system which will produce the most adequate and economical highway service. These fundamental purposes may be summarized under the following headings:

(1) To further apply business principles to highway planning and administration. This involves an analysis of the demand for highway service and a study of the most efficient and economical methods of providing it.

(2) To establish scientific methods of planning a highway system, and to set up scientifically planned highway development programs. This involves two factors:

(*a*) The determination of the highway improvements which are economically justified by the comparison of costs of the improvement with the value of the service yielded by the improvement, and

(*b*) The planning of the highway development program which will yield the maximum service for a given expenditure of funds, and the scientific determination of the order of improvement of the various highways within the system.

(3) To establish sound and equitable principles governing the distribution of highway costs. A scientifically planned highway system can not be developed unless the costs of the improvement are equitably distributed in proportion to the service yielded. The establishment of sound principles of highway finance requires an accurate evaluation of the service of the highways to various individuals and classes of society, the analysis of the present distribution of highway costs, and the comparison of these costs with the value of the service.

(4) To determine the place of highway transportation in our transportation system, and to establish the principles of coordination between highway transportation and other forms of transportation in order to develop the most efficient general transportation system. This involves a study of the present uses and volume of highway transportation, and a comparison of highway transportation with other methods of transportation with reference to costs, service, stability, and probable future development.

TYPES OF ECONOMIC RESEARCH

With these purposes in view a comprehensive program of economic research has been inaugurated and is progressing rapidly. Highway transportation and highway planning investigations have been completed in California, Connecticut, Maine, and Cook County, Ill. Field work has been completed on a similar project in Pennsylvania, and similar work is now in progress in Ohio. These investigations include the collection of complete traffic data upon the highway system of each area and provide basic data required for the establishment of a scientific improvement program, as well as very valuable information regarding highway transportation in relation to other forms of transportation.

A series of investigations dealing more particularly with the field and scope of motor-truck transportation, and supplementing the data obtained in the transportation and planning investigations, is also in progress. The results of studies of motor trucking in the Chicago metropolitan area, made in connection with the Cook County transportation survey, and dealing with the organization, operation, and costs of motor trucking, together with trucking rates and principal commodities hauled by motor truck, will soon be ready for publication. Similar investigations are also in progress in the New England and Middle Atlantic States.

A third type of research, dealing with the problems of highway financing, is also in progress. Large highway revenues are annually collected from rural real estate through general property taxes and also, in some jurisdictions, through special assessments for highway construction. It is the purpose of this series of investigations to measure quantitively the effect of highway improvements upon the value of rural land and to compare this effect with the cost to the land of the highway improvements. Field work of this investigation has been completed in selected areas of the State of Iowa and in an intensive dairying area of southern Wisconsin and northern Illinois. Data will also be obtained in selected areas of Ohio. The report of these studies will be made upon completion of the field work in Ohio.

RESULTS OF PLANNING STUDIES TO DATE

These studies, which have been undertaken in California, Connecticut, Maine, Ohio, Pennsylvania, and Cook County, Ill., have produced a great deal of information of special value to the authorities exercising jurisdiction over the highways of the several areas. In the State areas the problems have involved mainly the determination of the relative density and character of traffic on the various roads constituting the State highway system, the probable increase over a period of years, and the value of the traffic as a basis for a definite program of improvement and a fair distribution of the cost.

In Cook County the problem was considerably more complicated, the need more urgent, and the findings and recommendations are therefore of particular interest. A serious condition of congestion exists on the county highways adjacent to the city of Chicago. This condition, recognized by city, county, and State authorities, prompted the making of the survey as a means of establishing the facts of the situation and indicating the remedies.

It is not possible in this report to refer to the details of the findings and recommendations in each area, but there are a number of general conclusions, common to all, the more important of which may be mentioned as follows:

(1) It is possible by such investigations to indicate not only the highways upon which the need for improvement is greatest but also to indicate the type and design required to carry the traffic adequately on any route. They also prevent errors in the selection of routes for improvement and in the selection of proper type and design for these improvements. The prevention of such errors on one route may result in a saving equal to the entire cost of the investigation.

(2) The classification of highways on the basis of present and future traffic importance and the selection of the most suitable type of highway surface to serve traffic depends upon the type of traffic units as well as the number of these units. The more important considerations are:

(*a*) Density of present and future total traffic.

(*b*) The ratio of trucks to total vehicles.

(*c*) The proportion of trucks of large, medium, and small capacity.

(*d*) The maximum wheel loads.

(*e*) The frequency of heavy gross loads and wheel loads.

In individual cases other factors must be considered, but in general the most important considerations are those above mentioned. The final selection of the type of highway surface depends upon certain physical considerations, such as topography, drainage, soil and subgrade conditions, availability and cost of materials, as well as upon traffic considerations.

(3) A definite program of the order of improvement of various highways is essential to the production of efficient and economical highway service. Investigations in the several States have demonstrated the urgent need for improvement of certain highway routes or sections of such routes. Unimproved or insufficiently improved sections of important traffic routes prevent the full utilization of the entire route. To obtain the maximum service from the highway system it is essential that these sections be given priority in the improvement program. Investigations also indicate that upon insufficiently improved important traffic routes maintenance costs become excessive. In the interest of economy as well as of highway service such routes must be given priority in the improvement program.

(4) The traffic importance of the various roads of the highway system provides the only proper index for the distribution of highway funds.

(5) The location and design of highway improvements must consider future developments in traffic as well as present traffic. Investigations completed indicate that in various areas traffic using the highways in 1930 will be from 100 to 120 per cent greater than in 1924. Highway programs must be developed to adequately serve this great expected increase in traffic.

(6) Important passenger - traffic routes are in general identical with important truck-traffic routes. The ratio of trucks to passenger cars varies considerably on different routes, but exclusive trucking or exclusive passenger-car routes are practically unknown in the States where traffic has been analyzed, and important passenger-car routes that are not also important trucking routes, or vice versa, are few in number.

(7) Important traffic routes are generally found in the areas of dense population and intensive industrial development. The population and industrial development of the area served by highways are important factors in the determination of the traffic upon the route. On highways connecting two centers of population the population and industrial development of the centers and the distance between them are important traffic factors. This relationship between population and highway traffic indicates the necessity of considering population and industrial distribution in the planning of a highway system.

(8) Highways in the proximity of important industrial centers not only carry a large number of trucks but also carry a high proportion of large-capacity trucks with resulting heavy gross, axle, and wheel loads.

(9) On heavy-traffic routes considerations of economical highway service as well as of safety demand the removal of every obstruction to the free flow of traffic. Traffic congestion points such as railway intersections, important highway intersections, traffic "bottle necks," narrow bridges, and narrow or partly obstructed streets in villages through which the route passes, lower the capacity of the entire route and are economically unjustified.

(10) The provision of adequate entry ways for heavy-traffic routes into large cities is an important highway-planning problem. The convergence of several routes at one city gateway and the lack of adequate connections between these highways and city streets are frequent causes of congestion. In the congested-traffic areas adjacent to the larger cities traffic-sorting routes and belt highways as well as adequate city connections are essential.

(11) The development of a highway system to adequately serve traffic needs, particularly in the suburban areas surrounding large cities is frequently obstructed by the lack of provision of adequate right of way. A scientific plan of highway development should include the acquisition of right of way adequate to provide efficient service for the expected development of the area. Unless such right of way is acquired before the development of a suburban area, special-use districts, such as railway yards, industrial plants, parks, etc., may prevent the natural development of the highway system as well as

greatly increase the cost of future acquisition.

(12) Highway traffic, both of passenger cars and motor trucks, is predominantly local in nature. Long-distance movement is important on certain routes, but even in these cases the long-distance traffic is a relatively small part of total traffic. The results of the Connecticut transportation survey indicate that 55.7 per cent of all passenger cars make an average trip of less than 20 miles and 72 per cent less than 40 miles.

(13) Truck traffic is primarily a short-haul movement. The average trip mileage varies considerably in different areas, but in the areas studied between 55 and 70 per cent of all loaded trucks travel less than 20 miles per trip, and between 75 and 80 per cent have an average trip mileage of less than 30 miles.

THE MOTOR-TRUCK INVESTIGATIONS

The investigations dealing more particularly with the field and scope of motor-truck transportation and its coordination with other types of transportation are still in progress and conclusions are therefore less definite. The following important conclusions are evident:

(1) The movement of consumption goods and other goods to their place of final use is the most important motor-trucking movement. The hauling of perishable foodstuffs forms an important part of this movement.

(2) In the Chicago area it was found that the hauling by motor truck of perishable foodstuffs originated at railway team tracks, auction-house team tracks, storage houses, boat wharves, railway express terminals, parcel-post terminals, and at original producers in the territory surrounding the terminal area.

(3) In the same area the principal factors affecting the movement of perishable commodities by motor truck are:

(*a*) The nature of the commodity. Highly perishable commodities must be moved at once, either to market or to storage.

(*b*) Trade practices and market organization. The centralization of the produce market has resulted in congestion of motor trucking around these markets.

(*c*) Fluctuation of receipts. The daily and seasonal fluctuations in recepts creates a problem of unused equipment during periods of small receipts and problems of traffic congestion during periods of large receipts.

(*d*) Fluctuations of market demand. Heavy buying days in contrast with light buying days also result in problems of unused equipment and traffic congestion.

(*e*) Physical facilities at truck-loading points. Lack of adequate design of railroad team tracks and other truck-traffic loading points for motor-truck use frequently results in congestion and delay.

(4) Commercial motor trucking is a relatively small part of total motor trucking. On Cook County highways 83 per cent of all trucks are owned by the owner or shipper of the commodity hauled.

(5) Within the commercial-haulage industry a tendency toward concentration is evident. In the Chicago area approximately one-fourth of the firms own three-fourths of the equipment, employ three-fourths of the employees, and receive three-fourths of the gross revenue.

(6) A tendency toward the use of trucks of smaller capacity (3½ tons or less) in place of trucks of 5-ton and larger capacities is apparent. In certain areas the smaller trucks are being equipped with larger bodies.

(7) There is a decided lack of standardization in the commercial trucking business. Few, if any, standard record or shipment forms are used, particularly by the smaller companies. Complete operating-cost records for individual trucks, or even for fleets of trucks, are unknown to most companies. A few of the larger and better organized trucking companies keep cost records, but the cost systems as well as the analysis of costs and the application of the results as a central factor in management can be considerably improved. The creation of a depreciation fund to replace worn-out equipment is practically unknown among the smaller companies.

INVESTIGATIONS OF THE EFFECT OF HIGHWAY IMPROVEMENT ON LAND VALUES

Investigations of the effect of highway improvements upon rural land values are still in progress and final conclusions are not available. It is apparent, however, that there is a relationship between highway improvements and rural land values, and that this relationship is measurable. The effect of highway improvements upon the value of such land varies with several factors, and in general agricultu-

ral areas the variation in value resulting from different types of highway improvement is but a small part of the total farm value. In special-culture areas such as intensive dairy or truck farming sections highway improvements may be expected to have a greater effect upon land values than in general agricultural areas.

IRRIGATION INVESTIGATIONS

The irrigation investigations conducted by the bureau all have for their purpose the promotion of the economical use of water. The need of research of this character has never been greater than it is at present. In the early days of irrigation farming the supply of water was greater than the demand. This condition led naturally to the development of wasteful practices in the use of water which now must be abandoned not only because the demand is now in many sections greater than the supply, but also, in some cases, because the excessive use of water has caused the soil to become water-logged.

The general problem is being attacked from several angles. Naturally the first is the water requirement of the crops to be grown. How much water do they need? What method of irrigation is most favorable to the production of each, and at the same time most economical. At what stages of the growth is the water required and in what volume? Such questions as these we are endeavoring to answer in the studies of water requirements of crops conducted in cooperation with the New Mexico Agricultural Experiment Station and with the department of engineering and the agricultural experiment station of California. The former work has consisted of a study of various field crops and truck. In California the water requirements of alfalfa have been studied at Delhi, and of crops on the delta lands at the mouth of the Sacramento and San Joaquin Rivers. Other studies of the requirements of rice have been made in the Sacramento Valley.

A bulletin on "Water Requirements of the Arable Lands of the Great Basin" is now being printed and a second publication of the series, entitled "Water Requirements of the Arable Lands of the Missouri River Valley," is in course of preparation. The New Mexico Agricultural Experiment Station will publish a report prepared by the bureau on "Net Requirements of Crops for Irrigation Water in the Mesilla Valley, New Mexico," based on the cooperative studies conducted for the past several years; and the department of engineering of California has already published the results of the cooperative work in that State on cost of water to irrigators.

The object of scientific irrigation is to supply the volume of water required by the particular crop to be irrigated and no more. The volume of water applied, however, and the rate of application should bear a close relation to the water-holding capacity of the soil. Only the water that is held by the soil within reach of the plant roots is of benefit to the crop. Heavy irrigation of soils of low water-holding capacity is uneconomical, because the water quickly sinks into the soil beyond the reach of the plant roots. The immediate object of the studies of water-holding capacity which have been continued during the past year is to determine what relation, if any, exists between the water-holding capacity of various soils under field conditions and the moisture equivalent of the same soils as determined by the centrifuge method in the laboratory. The ultimate purpose is to provide a basis for estimating the water-holding capacity under the field conditions by means of the standard laboratory test on samples of the soil.

A large number of the field studies have been completed and determinations have been made of the moisture equivalent of the soils so studied. These have developed inconsistencies of such prominence as to demand explanation. The relation existing between certain physical properties of the sample, such as its size, and the resulting moisture equivalent as determined in the usual way has been determined and there is now under investigation the relation of the alkaline content of the samples to the moisture equivalent and the effect of leaching alkali soils upon the moisture equivalent. These studies will be continued as time and opportunity afford.

The question frequently arises in connection with the drainage of irrigated lands, as to how much of the water in saturated soil will be removed by drains placed at given depths below the surface. This question includes also the distribution of moisture not removed by drainage. These questions are receiving special field study as time permits.

Prominent among the losses incurred in the use and distribution of water are those resulting from evap-

oration, both from free-water surfaces, such as the surfaces of reservoirs, and from relatively saturated soil. Considerable additional data have been obtained during the past year on evaporation from a free-water surface, particularly at the Fort Collins (Colo.) hydraulic laboratory, and a progress report of this work has been prepared. These investigations are being extended, in cooperation with the Bureau of Reclamation, to include evaporation losses from large bodies of water. For this purpose the East Park Reservoir in California was selected. The natural inflow into the reservoir is very small during June and is easily measurable. During the spring accurate measurements were made of the inflow and of the evaporation loss as determined from the lowering of the elevation of the lake surface, there being no outflow. In addition to measurements of evaporation from the lake, the evaporation from tanks of special design was determined. Meteorological observations were also made, especially as to air movement and temperature. It is hoped to continue these observations next season. Their purpose is to determine the factors of relationship between the loss of water by evaporation from a standard evaporation tank and from a lake, reservoir, canal, or tanks of various sizes, in order that the results of experiments made with tanks may be properly interpreted.

Additional investigations were conducted to determine the evaporation losses from a relatively saturated soil. For this purpose cylindrical tanks about 30 inches in diameter and 2 to 4 feet deep, filled with various soils, were sunk in the ground until the tops were level with the ground surface. By means of a Mariotte bottle the elevation of free water was maintained at a constant distance below the surface of the soil in the tanks. It is expected to continue these investigations another year before attempting to draw conclusions.

A report on seepage losses from California canals and economic means for their prevention is nearing completion. Some time has been spent on similar studies in Texas, and a complete report will probably be made during the coming year.

The foregoing projects all have to do more or less directly with the prevention of water loss. Another group of investigations has been carried on with the object of improving the methods of water measurement by which the quantities supplied to irrigators are regulated. Studies of current meters have been continued with the object of perfecting the mechanical features of these instruments.

The improved Venturi flume designed by this bureau has been installed at the Fort Collins and Bellvue stations in Colorado under many different conditions for the measurement of quantities of water varying from a few to 200 or 300 second-feet. The wide range of test conditions has been made possible by the enlargement of the Bellvue laboratory.

A recording device is being developed for use with the new Venturi flume by the use of which it will be possible to show at any instant the quantity of water that has passed through the measuring device, and in addition the quantity passing at the time the instrument is read. Some work yet remains to be done in perfecting this instrument.

Some time has been devoted at the Fort Collins laboratory to the calibration of weirs and other measuring devices with the object of determining the limiting conditions under which they can be used satisfactorily in practice. The Colorado work at both stations has been conducted in cooperation with the State agricultural experiment station.

The bureau is also cooperating with the city of Denver in designing various water-measuring devices to be used in connection with the Denver water supply. It is the intention to test the accuracy of these devices when they are installed.

The studies of silt carried in the lower Rio Grande of Texas and in the Colorado River have been continued. In the case of the Colorado River investigations the preliminary investigations have been practically completed and a report is now being prepared giving the results obtained during the past 12 or more years in cooperation with the California Department of Engineering.

Studies of methods to control gravel in small streams in Utah, mentioned in previous reports, have been continued and extended. New structures have been put in between Box Elder County on the north and Iron County on the south and have proved very satisfactory in solving this vexing problem. Although the flood of Utah streams in 1924 was not excessive there was nevertheless a considerable run of gravel. The principle involved in the control of the gravel is that of

checking the rate of flow of water, thereby causing a deposition of a part of the load of débris carried by the stream. Measurements of the quantity of gravel deposited this year are being made and the cost of the control measures adopted will be determined. It is expected in the future to make this project subordinate to the project of utilizing stream flow for irrigation purposes. A complete report of the work is in preparation.

The field work on the flow of water in metal pipes has been completed and the preparation of the report is now under way. Additional tests have been made on the flow of water in flumes and in a short time the field work will be completed and the preparation of a report begun. Some additional tests were made on the flow of water in large concrete pipes at Tulsa, Okla., and Denver, Colo.

In cooperation with the Bureau of the Census and the Bureau of Agricultural Economics, the bureau has collected considerable data in the West on the sale and settlement of land in irrigation enterprises and the cost of farming under irrigation. In connection with the special agricultural census of 1924 and 1925 a questionnaire was prepared jointly by the two bureaus of the Department of Agriculture, and special enumerators were employed to collect the data. This information, together with that previously collected, is the basis upon which there is now being prepared a bulletin on the subject. It is expected to continue and enlarge somewhat upon certain features of this work.

The study of drainage run-off from irrigated lands has been made a major project. This question is of importance in that run-off is the basis for the determination of the required capacity of drains. Conditions on irrigated lands are so varied that an extended investigation appears necessary. The plan provides for the securing of run-off data from drained areas in most of the States of the West. In conjunction with this, information will be secured as to the quantity of water applied, the proportion of the whole area in crops, the structure of the soil and subsoil, meterological data, and such other features as may have a bearing upon the question. Use will be made, as far as possible, of data obtained by other agencies. The Bureau of Reclamation has a large amount of information on the subject, as have many of the irrigation districts.

Other investigations the result of which will shortly be published include the study of methods of water delivery which was begun in 1923, a study of the operations of mutual water companies, and the study of the drainage of irrigated lands in the Salt River Valley, Ariz., by means of pumping from wells.

The bureau is frequently called upon by other public as well as private agencies to make special investigations and reports. During the past year about 15 per cent of the work in connection with irrigation has been of this character. On account of the necessity of devoting more time to research this advisory work is being gradually curtailed.

Some time has been devoted to assisting in the organization of drainage districts in irrigated sections. Observations have been made of the methods employed for the drainage of irrigated lands and intensive studies of such systems have been made in some cases. Some attention has also been given to the drainage of so-called "alkali lands."

At the request of the Bureau of Reclamation of the Department of the Interior, a report has been made, in cooperation with the soils department of the Oregon Agricultural College, upon the agricultural and economic feasibility of the proposed Vale, Oreg., irrigation project.

A report of a similar nature was made on the Jefferson Water Conservancy District in Oregon, at the request of the governor and State engineer of Oregon, the investigation being made in cooperation with the division of soils of the Oregon Agricultural College, and the State engineer. Later the governor requested the Bureau of Reclamation to become a party to the investigation since that bureau might be asked to assist in or take charge of the building of the project if found feasible. Three possible plans were presented as follows: (1) The financing of the project as a water conservancy district under the State laws; (2) the cooperation of the Bureau of Reclamation with the conservancy district to the extent of building the dam and the completion of the reservoir; (3) the building of the entire works by the Bureau of Reclamation.

At the request of the congressional representative of Chouteau County, Mont., an investigation and report was made upon the feasibility of a water supply for domestic and stock-

watering purposes to serve the Lonesome Prairie section of that county.

DRAINAGE INVESTIGATIONS

The investigations of run-off from drained agricultural lands in the humid sections of the United States have been continued. The studies in the vicinity of Cape Girardeau, Mo., consist of obtaining rainfall and run-off data from one small watershed of about 180 acres with rough topography, from three hilly watersheds ranging in size from 10 to 35 square miles, from one flat watershed of about 25 square miles and from the watershed of the main diversion channel of the Little River Drainage District, about 1,200 square miles in area. In addition, gaging stations and slope courses have been maintained on the diversion channel of Little River Drainage District and the St. Francis River floodway near Marked Tree, Ark., for the purpose of determining the resistance to flow in cleared floodways and for different conditions of growth on floodways.

The results of measurements made on the watershed of 180 acres afford information of value in the design of road culverts, hillside diversion ditches and storm-water sewers draining agricultural areas. The data obtained on the larger hill areas are of value in the design of large diversion ditches and floodways and in the design of sedimentation basins and reservoirs for flood control. The run-off and other hydraulic data relating to the roughness coefficient in Kutters' formula for the dredged ditch draining flat land will be of use in the design of ditches with similar watershed characteristics in this and other sections of the country. A progress report of the investigations up to January, 1925, has been distributed. Subsequently additional measurements have been made following a rain of almost 5 inches over the various watersheds. Ordinarily such a rain would have caused excessive floods, but owing to the abnormally dry condition of the watersheds the maximum rate of run-off formerly recorded was exceeded on only one ditch. This storm brought out strikingly the effect of the condition of the watershed on run-off.

A report has also been prepared covering the investigations on the floodway of the Little River Drainage District which shows conclusively the importance of keeping flood ways cleared of growth to prevent an appreciable reduction in the discharge capacity, furnishes hydraulic data for use in the design of floodways and large dredged ditches, and recommends a new method for computing the combined flow in a channel and floodway based upon a study of equal velocity curves in the channel and adjoining floodway.

The run-off investigations at Urbana, Ill., mentioned in previous annual reports, have been continued. They involve the collection of rainfall and run-off data for 13 watersheds and the determination of the roughness coefficient in Kutter's formula for the channels draining these watersheds. Five additional stations have been established during the past year, three of these on dredged ditches and two on large tile outlets. These stations replace five of the old stations where fairly complete data had been obtained. A progress report on these investigations covering the work up to January, 1925, has been prepared, so that the results might be immediately available to engineers. The report shows conclusively that where ditches are not kept clear of growth a very high resistance to flow obtains which greatly reduces the discharge capacity as compared with that of a cleared ditch, thus indicating that the maintenance of ditches in good condition is an important factor in obtaining efficient drainage. The data obtained will be of use in the redesign of many inadequate drainage ditches throughout Iowa, Illinois, Indiana, and Ohio where the characteristics of the watersheds are similar to those investigated.

Run-off investigations have also been continued at Cleveland, Miss., and a progress report has been prepared covering the results to January, 1925. Rainfall and run-off data are collected here on a watershed consisting of practically flat land and a determination made of the roughness coefficient in Kutter's formula for dredged ditches and for one large natural channel. Two new gaging stations have been added within the past year.

Similar investigations have been started within the past year at McGehee, Ark. Six of the channels on which gaugings are being made are in the Cypress Creek Drainage District. These will permit of a comparison of the rates of run-off obtained in this district with the values given by the run-off curve used in the design of these channels, and which is quite

generally used by practicing engineers who plan drainage improvements, particularly in the Mississippi Delta region.

Ground-water investigations on tiled areas were started in 1925 on the State experimental farms near Stoneville, Miss., and Urbana, Ill. The purpose is to obtain much needed data on the design of tile-drainage systems, such as the proper spacing and depth of tile for different types of soil. The fluctuations of the ground-water level are determined by means of test wells.

The hydraulic-research investigations on the flow of water through concrete box culverts conducted during the past fiscal year in cooperation with the State University of Iowa have been completed. The tests made on several sizes of culverts have led to the development of new discharge formulas for culverts.

Tests were made at the Iowa laboratory on nine different types of current meters to determine the effect of eddies on the various meters. In addition, tests were made to determine the effect of diagonal currents on meters. The Price meters were also tested with each meter tipped upstream and downstream. All meters were tested in four velocities, namely, 1, 2, 3, and 5 feet per second. The results of the tests show that for certain meters the impact on the meter wheels will cause an over registration of 100 per cent. A complete report covering the investigations will be made during the present fiscal year.

In cooperation with the University of Minnesota and the department of drainage and waters of Minnesota the bureau is continuing the investigations of the effect of alkali waters on drain tile at the University Farm, St. Paul, Minn. This laboratory was established July 1, 1921, primarily to facilitate studying the effect of so-called "alkali" water on drain tile made of Portland cement concrete with special reference to the conditions of southwestern and western Minnesota where tile failures in public drains were first noticed early in 1919 and have continued to develop up to the present season. In 1923 the work of the laboratory was broadened to include studies of the action of the peat and muck soil of Minnesota and Wisconsin on concrete drain tile. The work in Wisconsin is being conducted under an informal cooperative agreement with the department of agricultural engineering of the University of Wisconsin.

Combined with the research work a certain amount of routine work is done by the laboratory, consisting of testing drain tile for engineers, manufacturers, and individuals, and examining for alkali soil waters submitted by engineers from areas in which the use of drain tile is contemplated.

Experimental cylinders of many different types of concrete have been exposed to artificial sulphate solutions in the laboratory and to natural waters under various field conditions. These conditions are briefly as follows:

Cylinders have been stored in the laboratory in tap water very low in total salts and compared with others installed in Medicine Lake, Minn., which has a salt content of 4.5 per cent consisting almost entirely of sulphates. Drain tile have been laid in soil containing various percentages of sulphates. In two installations the soil is well drained; a third is along the margin of a slough where the bottom of the tile is continuously wet and the top usually only damp. Drain tile have also been submerged along the margin of Medicine Lake, Minn. Cylinders and drain tile have been installed in peat at four locations in Minnesota and at an equal number of locations in Wisconsin. In some cases the specimens are continuously covered with water, while in others they are merely moist. They are laid at depths varying from 20 inches to 5 or 6 feet.

As yet no complete report has been issued. The following papers have been published covering various phases:

Report of concrete-alkali investigations in Minnesota 1919–20. Published July, 1921, by State of Minnesota, Department of Drainage and Waters.

Laboratory investigations of the influence of curing conditions and various admixtures on the life of concrete stored in sulphate solutions as indicated by physical changes. Proceedings of American Society for Testing Materials, Vol. 24, Part II.

Curing conditions of concrete drain tile, a factor of resistance to sulphate waters. *In* Concrete, June, 1924.

Volume change a measure of alkali action. *In* Public Roads, June, 1924.

Among the problems confronting the sugar-cane growers in the region of the Gulf coast of Louisiana are those due to the variable rainfall. Extended periods of excessive rainfall damage the crop with more or less frequency and periods of drought seriously retard the growth at others. As anticipated, the experiments in irrigation now being carried on by the bureau gave gratifying results during the past season with its very scanty rain-

fall, whereas those in connection with drainage were not so conclusive. However, it is only the average results over a period of years that can demonstrate whether a profit may be expected either from a more intensive drainage or from irrigation, and the work started three years ago accordingly has been continued.

The study made at Cocoa, Fla., of the variation of soil moisture in citrus groves has been concluded, and the final report on the investigation has shown that both excess of, and deficiency of moisture occur much oftener and to a greater extent than had hitherto been suspected, and indicate that the amount of moisture present may have an important bearing on the life of the trees.

The studies of erosion from cultivated fields were continued in North Carolina. It was found that the amount of soil removed from the plot where the heaviest erosion occurred during one period of heavy precipitation exceeded 1 pound per square foot of area. Further study is needed before final conclusions are drawn, but it is hoped that these investigations will afford a definite answer to the farmer who wants to know how to vary the spacing of his terraces in order to insure a minimum of erosion with as few terraces as possible.

FARM MECHANICAL INVESTIGATIONS

The large increase in the cost of producing crops, together with a rapidly decreasing supply of farm labor, has accentuated the need of using more power and mechanical equipment in performing farm work.

During the past 75 years the volume of production of the average farm worker has increased about threefold, due chiefly to the substitution of power and machinery for hand methods. Yet, at the present time, the volume of production per worker ranges from about 12 crop-acres per year in some States to 160 or more in others. A significant fact in this connection is that the volume of production in each State is practically in the same ratio as the quantity of machinery and power utilized per worker.

A large proportion of the farms are not yet using efficient methods of production. This is either because of a lack of appreciation of the value of modern machinery, insufficient knowledge of how to use such machinery, or because the equipment has not been properly designed to meet given conditions.

Since under present conditions power and labor combined represent, on the average, approximately 60 per cent of the total cost of carrying on a farm business, and as these two items are the chief ones over which the farmer can exercise direct control, greater opportunities for reducing the cost of production would appear to exist through increase in the efficient application of power and machinery than by any other means now available.

An analysis of the saving in labor and reduction in production costs that may be obtained by using various types and sizes of farm equipment is now being prepared and will be submitted for publication.

An appraisal of the total amount of power used on farms in the United States, completed during the past year, showed that agriculture uses as much primary power as all manufacturing and public utilities combined. The cost of this power exceeds $3,000,000,000 annually. Approximately 60 per cent of the power utilized is supplied by work animals; 21 per cent by tractors and motor trucks; 12 per cent by stationary engines; 6 per cent by electrical apparatus and 1 per cent by windmills. About 15 per cent of this power is used for plowing and listing and an equal amount for road hauling; 7.5 per cent is used for farm hauling; 7.5 per cent for threshing; 5 per cent for irrigation and drainage pumping, with a similar amount for fitting ground, planting, seeding, and haying; 5 per cent for harvesting, and about 4 per cent for the pumping of water for domestic purposes.

Serious difficulties are encountered in the efficient use of power for farm work due to the extreme seasonal demands of many of the farm commodities, the diversity of the operations, the small size of the existing power units and the low-load factor or small percentage of the time the power unit is used. As the result of these variables the cost per unit of power utilized on farms is relatively high.

Most of the agricultural machinery now in use has been developed to the point where it not only saves labor but in most cases will do the work considerably better than it can be done by hand methods. However, little scientific study has been devoted to the basic requirements of the operations to be performed or to ascertain whether or not the methods used ac-

complish the desired results with a minimum of labor and power input. Tests conducted at one of the experiment stations have shown that the power required to cut and elevate silage may be reduced 50 per cent by employing proper speeds and a blower of proper design. What saving could be shown if such a study were applied to the oldest and most used of all farm tools—the plow? The fundamental requirements of this implement are still undetermined; and no satisfactory method of measuring the actual work done by it has been developed. Power for plowing costs the farmers of the United States over half a billion dollars annually. If, therefore, a reduction of only 10 per cent in the draft of the plow could be effected a very considerable reduction in the cost of producing crops would be realized.

A bulletin has been issued summarizing the information now available on the use of power in agriculture which is intended to serve as a basis for further research into the problems of the more efficient use of power by the agricultural industry.

As a step toward the efficient use of implements a study of the problems of tractor farming in California was made during the year in cooperation with the University of California. A larger amount of power per acre is required in California than in any other State and this item of expense is a serious factor in the cost of producing crops. The cost of horse feed is high and horse power is proportionately expensive. However, the types of farming followed in California are especially adapted to the use of tractor power, and as a result more than half of the field power is supplied by this means. Local conditions require extra care on the part of the operator and special contrivances to keep dust from the wearing parts of the tractor, thus presenting mechanical problems that are not ordinarily encountered. A bulletin is in preparation in which it is intended to offer suggestions and instructions to operators on how to care for tractors and obtain satisfactory results in their use, and also to impress upon tractor manufacturers the need for special dust-proof construction in their product.

The design and size of tractors has materially changed in the last few years; hence a revision of Farmers' Bulletin No. 1045, "Laying out Fields for Tractor Plowing," was made in cooperation with the Bureau of Agricultural Economics.

A recent trend toward the use of high-grade fertilizers has introduced new problems in methods of distribution. In order to study the best form in which to use fertilizer and the most efficient means of distributing definite quantities on the field, a study of the mechanical problems is being conducted at the Arlington Experimental Farm in cooperation with other bureaus of the department. Soon after this project was begun it was realized that the physical condition of the fertilizer was an important factor which must be controlled. Due to the hydroscopicity of the fertilizer, experiments were required to determine the best conditions for handling it. To carry out this phase of the work a wide range of air conditions was required which necessitated the construction of an especially insulated room and the design and installation of air-conditioning apparatus for controlling temperature and humidity. The project is well under way and many interesting facts are being brought to light.

The work of developing and testing cotton-dusting machines and equipment for spreading insecticides to poison the cotton-boll weevil has been continued through the year in cooperation with the Bureau of Entomology, with headquarters at Tullulah, La. Special attention has been given to the design, construction, and testing of improved dusting apparatus for installation in airplanes. Studies have been made of electrical charges imparted to dust particles when delivered from ground machines and airplanes and also of the atomization and width of spread of insecticide dusts delivered from airplanes and different types of ground machines. Further work will be done during the coming year to determine the most efficient manner of flying for cotton dusting.

The investigations, in cooperation with the Bureau of Plant Industry, in connection with the transportation of fruits and vegetables have included a continuation of the study of the effect of body icing, or the placing of ice in direct contact with the lading, in refrigerator cars. Preliminary tests indicated that the efficiency of the floor insulation in cars of the older type is appreciably affected by the water from the melting ice. Further tests with cars of modern type indicate that such cars are less seriously affected, especially when new. The extent to which liability to damage increases with the

length of service of the car has not yet been determined. This work will be conducted during the ensuing year in cooperation with the Interstate Commerce Commission.

To determine to what extent precooling can be effectively employed to replace body icing, a portable plant has been designed and is being constructed. This equipment is capable of precooling carload shipments and will be used at shipping points in connection with the body-icing investigations. The same equipment will be available also for future investigations of the ice-water method of precooling fruits and vegetables which has recently come into use to a limited extent and appears to present important advantages over previous methods in the shipment of certain green vegetables and fruits.

Additional electrical and refrigerating machinery and equipment have been installed at the cold-storage laboratory, Arlington Experimental Farm, under the supervision of this bureau.

Because of the many requests for advice concerning oil burners for house heating, an investigation is being conducted, in cooperation with the Bureau of Home Economics, to obtain first-hand information in regard to the efficiency and operating characteristics of commercial oil burners. To carry on this work a laboratory was fitted up at the Arlington Experimental Farm with four different sizes of boilers of a type in common use in average dwellings. So far 15 makes of burners have been tested to determine the variation in fuel consumption under different operating conditions and to bring out other economic facts. This project has required a large number of tests and will have to be continued into the coming year before a final report on the findings can be made.

Farmers' Bulletins have been prepared to furnish information on the subjects of small concrete structures, rammed-earth buildings, farm plumbing, and farm water supplies, and working drawings have been prepared for special types of farm buildings. The classified list of farm-building plans, prepared jointly with the State colleges of agriculture, has been revised to include bulletins and recently issued drawings.

DISTRIBUTION OF SURPLUS WAR EXPLOSIVES FOR LAND CLEARING

On July 1, 1924, the bureau had 57,092,000 pounds of smokeless powder and approximately 10,000,000 pounds of sodium nitrate on hand, in magazines at Old Hickory, Tenn., and at Tullytown, Pa. It had previously investigated the problem of making an economical use of these explosives and had developed a formula for a commercial explosive composed largely of the two ingredients. The name "pyrotol" was given this explosive. Bids for the preparation of 100,000,000 pounds of the explosive were received from five bidders and the bid of E. I. DuPont de Nemours & Co. was accepted, but before the contract was signed a fire at the Old Hickory powder plant destroyed about 20,000,000 pounds of the smokeless powder which was to have been made into pyrotol under the contract. This loss decreased the quantity of pyrotol to be manufactured from 100,000,000 pounds to 66,000,000 pounds. However, a contract was finally signed for the preparation of the smaller quantity of pyrotol at the price of $0.0733 per pound previously submitted.

Immediately upon the signing of the contract on September 8, 1924, the Dupont Co. began the manufacture of pyrotol at three of its plants at Barksdale, Wis., Dupont, Wash., and Gibbstown, N. J. The shipments made from each plant are shown by months in Table 18.

TABLE 18.—*Pyrotol shipments, fiscal year 1925*

Month	From Barksdale	From DuPont	From Gibbstown
1924	*Pounds*	*Pounds*	*Pounds*
August			20,400
September	302,700	212,550	113,350
October	574,600	439,300	150,350
November	1,060,700	416,500	298,450
December	694,100	777,300	340,000
1925			
January	243,100	876,900	390,000
February	754,050	676,700	172,100
March	843,600	574,750	53,350
April	1,064,250	107,250	300,800
May	793,950	256,450	174,150
June	431,500	253,600	235,000
Total	6,762,550	4,591,300	2,247,950

The total production at the three plants for the fiscal year amounted to 14,352,200 pounds; the total shipments as shown in the table were 13,601,800 pounds. The 750,400 pounds in storage on July 1, 1925, were distributed as follows: Barksdale, 335,250

pounds; DuPont, 346,700 pounds, and Gibbstown, 68,450 pounds.

Of the 13,601,800 pounds shipped, 3,127,900 pounds were on Government and highway-construction orders, 10,473,500 pounds were for agricultural use, and 400 pounds were used for experimental purposes. Table 19 shows the distribution by States of the pyrotol used for agricultural purposes.

TABLE 19.—*Distribution of pyrotol for agricultural purposes*

State	Weight	State	Weight
	Pounds		*Pounds*
Alabama	106,500	Nebraska	79,700
Arkansas	8,850	New Jersey	2,600
California	64,000	New York	15,350
Connecticut	18,100	N. Carolina	700,150
Georgia	33,200	Ohio	72,000
Idaho	227,900	Oregon	1,021,400
Illinois	44,300	Pennsylvania	49,000
Indiana	73,500	S. Carolina	101,000
Iowa	280,000	S. Dakota	59,000
Louisiana	15,500	Tennessee	67,600
Maryland	9,000	Texas	87,100
Michigan	820,800	Virginia	48,000
Minnesota	1,947,300	Washington	1,738,450
Mississippi	18,000	W. Virginia	250
Missouri	89,600	Wisconsin	2,468,500
Montana	206,850		

Pyrotol used by farmers was distributed in cooperation with the State agricultural extension services in all the States listed except California, Connecticut, and Pennsylvania. No charge was made for the explosive ingredients furnished by the Government but the farmers were required to pay for the cost of preparation, the freight, an overhead charge of one-half cent per pound to this bureau, and an equal charge to the State extension service for its expenses in connection with the distribution. The overhead fund collected by the bureau was used to pay the cost of storing, guarding, and consolidating the surplus war explosives while the fund collected by the States was used for office expenses and for educational and demonstration work in connection with the distribution of the pyrotol.

The pyrotol distributed during the fiscal year 1925 has resulted in a saving to farmers of at least $890,000. This figure was obtained by comparing the weighted average delivered cost of pyrotol, namely, 8½ cents per pound, with 17 cents per pound, the manufacturer's delivered price on an equivalent quantity of commercial explosive in carload lots. If the usual retail price of commercial explosives had been used, the indicated amount saved would be several million dollars.

The indirect benefits to the farmers are much greater than the mere money saving and are of a permanent character. This cheap explosive has been used by the agricultural extension service to interest farmers in getting rid of stumps and bowlders so that the area of cultivated crops per farm can be increased and larger yields per acre obtained. The extension workers have preached individual farm efficiency and have offered this cheap explosive as one means of getting farmers started along this line of improvement. At least 95 per cent of the pyrotol distributed to farmers has been used in removing stumps and stones from cultivated fields and in adding a few acres more of cultivated land to existing farms. It is safe to say that none of it has been used to induce settlement on new or cut-over lands.

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., October 15, 1926.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1926, covering the work done in connection with the construction of Federal-aid and national forest roads and the economic and physical researches made in the highway field. A report of the work done by the agricultural engineering division of the bureau is submitted separately.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

Hon. W. M. JARDINE,
Secretary of Agriculture.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

The Federal-aid road projects completed during the fiscal year contributed a net addition of 9,417.3 miles to the mileage of improved roads in the Federal-aid highway system. Added to the mileage improved with Federal assistance in previous years, the above brings the total length of improved Federal-aid roads up to 55,902.8 miles.

At the close of the year construction was in progress on 10,961.8 miles and projects involving the improvement of 2,469.5 miles additional had been approved. Including the mileage of projects in these latter stages, all of which is included in the Federal-aid system, the total mileage improved or in process of improvement with Federal aid was 69,334.1 miles. With the exception of a few hundred miles improved prior to the designation of the Federal-aid highway system in 1921, all of this mileage is included in the system.

The highways included in the system now have an aggregate length of 182,134.8 miles. All have been selected by the constituted State and Federal highway officials as essential links of a system adequate for the accommodation of interstate traffic. Naturally there are degrees of importance even among these selected roads, but compared with the 3,000,000 miles of other highways in the country they are the most important of the Nation's highways and their improvement is absolutely essential for the proper accommodation of interstate highway traffic.

It is entirely consistent with the interests of the Federal Government to participate in the improvement of every mile of the designated system, but that will not be necessary. With negligible exceptions the roads included in the Federal-aid system are also parts of the several State highway systems. This is inevitable from the fact that important interstate roads are almost invariably essential State arteries also; and because of its importance to the States a very considerable mileage included in the system had already been improved prior to its designation.

The net mileage requiring construction in order to complete the improvement of the system, has, therefore, always been considerably less than the mileage of the system, and the work of improvement has always been carried on by the States independently as well as in cooperation with the Federal Government. In fact, as shown in Table 1, the State reports indicate that the mileage independently improved is in excess of that improved with Federal assistance; so that it is probable that the mileage within the system at present initially improved or in process

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of improvement is not far from three-quarters of the total.

It is, however, not the intention to imply that the work of improvement is three-quarters done. Much of the betterment that has been effected is merely the first step toward the improvement that will ultimately be required. Of the nearly 56,000 miles improved with Federal aid nearly 10,000 miles are unsurfaced, the improvement consisting merely of the proper grading and draining of the road bed. An additional large mileage is surfaced with sand-clay and gravel.

TABLE 1.—*Federal-aid mileage completed during the fiscal year 1926, including original and stage construction, compared with total mileage completed in 1925 by the State highway departments*

Group of States	Federal-aid mileage (original and stage construction) completed, fiscal year 1926	Mileage completed by State highway departments, 1925	Ratio of Federal aid to State program
	Miles	*Miles*	*Per cent*
New England	161.4	631.0	25.6
Middle Atlantic	785.7	1,687.4	46.6
South Atlantic	1,239.6	3,201.9	38.7
East North Central	836.8	4,321.1	19.4
West North Central	3,365.3	6,538.5	51.5
East South Central	1,046.6	1,113.5	94.0
West South Central	1,384.0	3,165.9	43.6
Mountain	1,300.6	1,483.1	87.6
Pacific	490.4	1,009.8	48.6
Total	10,610.4	23,152.2	45.9

As traffic is constantly increasing, these roads can not long be permitted to remain as they are, and there is a definite agreement between the State and Federal agencies that they will be further improved as traffic requires and funds for the purpose become available.

All such improvements have been made in conformity with the policy of stage construction under which the condition of the highways, where traffic permits, is gradually advanced to the ultimate state of improvement with high-class surfacing or pavement by successive stages. An exactly similar policy was followed by the builders of the railroads, whose first object was to "get the traffic through," leaving until a later date the perfecting processes of ballasting, banking of curves, etc. It is the only satisfactory method of dealing with the conditions existing in many of the Southern, Middle Western, and Western States in which there are thousands of miles of main road still entirely devoid of any improvement whatever.

That the purpose to continue the improvement as required is being conscientiously fulfilled is indicated by the fact that during the fiscal year secondary stages of improvement were completed on 1,193 miles previously improved with Federal aid. This work, involving the construction of 886.7 miles of gravel surfacing, 195.7 miles of concrete pavements, and smaller mileages of several other types of surfacing, is not represented in the 9,417.3 miles reported as improved, all of which was original improvement, and does not add to the total of 55,902.8 miles improved up to the close of the year. From the standpoint of the year's work, however, it does represent an accomplishment; and it may, therefore, be said that the mileage improved during the year was actually 10,610.3 miles, which exceeds the performance of any previous year except the last when 11,328.6 miles of original construction were completed.

IMPROVEMENT OF TRANSCONTINENTAL ROADS APPROACHING COMPLETION

Ten years ago, when the Federal-aid plan was adopted, there were only five States in which there was a single improved trans-State highway. They were Massachusetts, Connecticut, New York, New Jersey, and Maryland, all Eastern States, and all of that small group in which the movement for better highways was begun in the nineties.

In 16 States there was then no State highway department nor the semblance of a plan for the development of through routes across the State; and even of those States in which a recently created State agency was feeling its way toward a more scientific and businesslike administration of State highways there were few in which the conception of a connected State highway system had yet been clearly apprehended.

To-day 25 States have continuously improved highways entirely across them in at least one direction and 16 of these have completed such trans-State arteries in two directions.

It is the primary purpose of the Federal-aid road legislation to expedite the continuous improvement of such cross-State highways in all States and finally to provide a completely articulated system of main interstate highways for the Nation. The goal, as

represented by the Federal-aid highway system, is clearly defined and progress toward it has proceeded for the last five years at least without deviation. That progress will be continued with a more pronounced singleness of purpose in the future until it shall be possible to travel by highway without obstacle in any direction across all States and throughout the Nation.

There is now one transcontinental road which is 97 per cent improved. It extends from Washington through St. Louis, Texarkana, and El Paso to San Diego. Of its entire length 93 per cent is surfaced and 4 per cent is merely graded and drained; and of the surfaced portion more than half is improved with bituminous macadam or better and the remainder is gravel. From Washington to St. Louis there is no unimproved section and nearly 96 per cent is surfaced with bituminous macadam or some higher type of pavement. From St. Louis to Texarkana 2 per cent of the distance is unimproved and 63 per cent is improved with a gravel surface, the rest with superior types. From Texarkana to El Paso there are unimproved sections to the amount of 4 per cent of the distance, gravel surfaces 50 per cent, and bituminous macadam or better the rest of the way; and from El Paso to San Diego, with the exception of 6 per cent of the distance, the route is surfaced 60 per cent with gravel or equivalent and the remainder with pavements and surfaces of higher types.

This road from Washington to San Diego is more nearly completed than any other transcontinental route. Of its total length of 3,133 miles, 2,907 miles are surfaced and 131 miles are graded and drained, leaving only 95 miles without improvement.

Next in point of improvement is the route from Atlantic City, N. J., to Astoria, Oreg. Of its total length of 3,240 miles, one-eighth is still unimproved, nearly another eighth is graded and drained, and the rest is improved with some form of wearing surface. Of other east-and-west routes, that from Norfolk, Va., to Los Angeles is 68 per cent improved; and from Chicago to Los Angeles, partly by this same line, is 63 per cent improved. From Boston to Seattle through the northern tier of States the most direct through road is 73 per cent improved and 69 per cent surfaced either with permanent or temporary surfacing.

TYPES OF FEDERAL-AID ROADS

The 9,417.3 miles involved in the projects completed during the year consist of 2,161.3 miles of graded and drained earth roads, 627.3 miles surfaced with sand-clay, 3,274.1 miles with gravel, 58.2 miles with water-bound macadam, 553.2 miles with bituminous macadam, 179.6 miles paved with bituminous concrete, 2,464.3 miles of Portland cement concrete, 78.1 miles of brick, and 21.3 miles of bridges more than 20 feet in span.

The earth, sand-clay, and gravel roads are mainly in the South and in the States west of the Mississippi. Of the 6,062.7 miles of these three types completed during the year only 187.4 miles are in the Northern and Eastern States. The small mileage of water-bound macadam is scattered among the States of all geographic groups except the Middle Atlantic, West North Central, and Pacific; and the several higher types of construction including bituminous macadam and better are found in all sections, forming the highest percentage of the total however in the Northern and Eastern States.

A similar sectional distribution of the several types of construction exists with respect to all highways constructed with Federal aid; and, as shown by Table 1, there is an appropriate relation between the types constructed in the various geographic sections and what may be termed the potential motor vehicle traffic as represented by the ratio of motor vehicle registration to mileage of the Federal-aid system in each section.

TABLE 2.—*Relation of potential motor vehicle traffic and types of Federal-aid roads completed to June 30, 1926*

Geographic division	Number of motor vehicles per mile of Federal-aid system [1]	Percentage of mileage of roads completed	
		Bituminous macadam and higher types	Water-bound macadam and lower types
Middle Atlantic	343	98.5	1.5
New England	223	70.8	29.2
Pacific	193	35.2	64.8
East North Central	187	70.3	29.7
South Atlantic	85	35.9	64.1
West South Central	74	21.8	78.2
West North Central	62	14.2	85.8
East South Central	61	25.5	74.5
Mountain	32	9.5	90.5
All States	109	31.4	68.6

[1] As registered in the several States during the calendar year 1925.

In Table 2 the several geographic divisions are arranged in the descending

order of the ratio of their motor vehicle registration to the mileage of the Federal-aid highway system in each; and it will be observed that with the exception of the Pacific and East South Central groups the several divisions would be rated in the same order on the basis of their percentage of mileage suitable for medium and heavy motor vehicle traffic.

In addition to the 9,417.3 miles of original construction completed during the year, stage construction was completed on 1,193 miles, all of which had been previously constructed to lower type with Federal aid. This secondary construction was divided by types as follows: Sand-clay, 7.8 miles; gravel, 886.7 miles; water-bound macadam, 6.8 miles; bituminous macadam, 46.3 miles; bituminous concrete, 49.5 miles; Portland cement concrete, 195.7 miles.

That this process of gradual improvement is being continued at a desirable rate is indicated by the fact that stage construction was in progress on 1,328.9 miles, including 943.6 miles of gravel, 75.3 miles of water-bound macadam, 36.5 miles of bituminous macadam, 44.9 miles of bituminous concrete, 227.8 miles of Portland cement concrete, and 0.8 miles of brick.

Both in mileage of stage construction completed and in mileage under construction the West North Central States led all other groups by a wide margin, the Mountain and South Atlantic States being next in order. No work of this character has been undertaken in the New England or Middle Atlantic States and only a relatively small mileage is in the East North Central States. From Table 1 it will be observed that these are the groups in which the original construction is predominantly of the highest character, and in which there is consequently the least need for further improvement.

In view of the general increase in motor-vehicle traffic throughout the country it is interesting to observe from Table 3 that the greatest increase in mileage was of those types, including the gravel, bituminous, and pavement types, which are most suitable for motor-vehicle traffic.

TABLE 3.—*Mileage of Federal-aid highways at the close of the fiscal years 1925 and 1926 and percentage of increase*

Type	Mileage at close of fiscal year 1925	Mileage at close of fiscal year 1926	Percentage increase during fiscal year 1926
Graded and drained	9,079.2	[illegible]	6.3
Sand-clay	4,446.3	[illegible]	10.8
Gravel	18,013.8	[illegible]	25.1
Water-bound macadam	1,032.2	1,123.3	8.8
Bituminous macadam	2,564.2	3,176.3	23.8
Bituminous concrete	1,370.5	1,626.1	18.6
Portland cement concrete	9,234.6	11,976.6	29.8
Brick	644.2	752.0	16.8
Total	46,385.0	55,781.5	20.2

The types least suitable for motor-vehicle traffic are the graded and drained earth roads, and those surfaced with sand-clay and water-bound macadam; those preeminently adapted to such traffic are the bituminous types, concrete and brick. Although the new construction of the first groups amounted to 30.3 per cent of the total new mileage, the net addition of mileage of this character was only 12.2 per cent of the total net increase; the net increase of the types most suitable for motor traffic was 39.5 per cent, although the new mileage of these types constructed was only 34.9 per cent of the total new mileage. The gravel type, which is the cheapest type capable of resisting moderate motor-vehicle traffic and the usual choice for the secondary improvement of earth roads, increased 48.2 per cent in net mileage, although in the new construction it constituted only 34.9 per cent. These differences between the new construction and net increases of the several types reflect the beneficial results of the stage construction.

TWENTY-ONE MILES OF BRIDGES COMPLETED

The 21.3 miles of bridges completed, while by no means comparable with the large completion during the preceding year, represent a very considerable addition to the list of important bridges constructed with Federal aid. Including the structures just completed the aggregate length of all completed bridges was 121.6 miles.

All of these structures are more than 20 feet in span, and four completed during the year are longer than a mile. These bridges, which are among the longest in the country, are the interstate bridge over the Savannah River near Savannah, Ga., 1.6 miles in length; the bridge over the Missouri River near Lexington, Mo., 1.4 miles long; the bridge over the Raritan River at Perth Amboy, N. J., 1.6 miles long; and the Lake Champlain bridge near Milton, Vt., which is 1.2 miles in length.

A list of the bridges completed during the year which cost $75,000 or more is given in Table 4. These, the longest structures completed, vary in length from a tenth of a mile to more than 1½ miles, and have an aggregate length of 12.7 miles, more than half of the mileage completed. The remainder is made up of numerous smaller and less expensive structures.

TABLE 4.—*Federal-aid bridges completed during the fiscal year 1926 at a cost of $75,000 or more each*

State	Location	Stream	Length
			Miles
Alabama	Between Demopolis and Livingston	Tombigbee River	0.5
Do	Between Florence and Huntsville	Shoal Creek	.2
California	Between Rio Dell and Fortuna	Van Duzen River	.2
Georgia (interstate)	Between Augusta, Ga., and Ellenton, S. C	Savannah River	.1
Do	Between Savannah, Ga., and Ridgeland, S. C	do	1.6
Georgia	Between Atlanta and Alpharetta	Chattahoochee River	.2
Mississippi	Between Jackson and Forest	Pearl River	.3
Missouri	At Glasgow	Missouri River	.4
Do	Between Waverly and Carrollton	do	.4
Do	At Lexington	do	1.4
Nebraska	Between Broadwater and Bridgeport	Platte River	.5
New Jersey	At Perth Amboy	Raritan River	1.6
Do	At Point Pleasant	Manasquan River	.6
North Carolina	At Winton	Chowan River	.1
Oklahoma	Between Cleveland and Hominy	Arkansas River	.3
South Carolina	At Georgetown	Black River	.5
Do	Between Greenwood and Mountville	Saluda River	.2
South Dakota	At Chamberlain	Missouri River	.3
Tennessee	At Clarksville	Cumberland River	.7
Do	Between McMinnville and Sparta	Caney Fork River	.1
Texas	At Richmond	Brazos River	.4
Utah	At Riverdale	Weber River	.5
Vermont	Between Milton and South Hero	Lake Champlain	1.2
Washington	At La Center	East Fork Lewis River	.2
Do	Between Ferndale and Bellingham	Nooksack River	.2
Total			12.7

Reference has been made in previous annual reports to the exceptional benefit of Federal aid in the construction of these bridges, especially the longer ones. The spanning of a wide stream is an expensive undertaking and calls for the concentration at one point of a sum of money which represents often a considerable part of the State highway revenues available during the period required for its construction. Consequently the construction of such bridges is put off sometimes indefinitely. Yet their very size gives them a position of commanding importance in the highway system. Necessarily the number of crossings of wide streams must be very few. If built, therefore, a bridge over such a stream carries a traffic which converges upon it from scores, perhaps hundreds of miles upstream and down, and if its construction is delayed traffic on a main State and interstate line of travel may be diverted a hundred miles or more out of the direct course. Faced with this alternative it is easy for the State to contemplate the issuance of a franchise for the construction of a toll bridge and thus avoid the necessary outlay of capital and put the burden upon the users of the bridge—a burden which includes a profit for a private corporation and which must still be borne in most instances long after the investment has been repaid by earnings.

From the Federal point of view the matter is of vital interest because, as stated above, these large structures are

focal points of traffic and almost invariably are controlling points on interstate routes. If the people of a single State are willing to pay toll for the use of a necessary bridge within their borders they have it in their control to deal with the matter in that way. But when the bridge in question lies upon an important interstate route and is used regularly by citizens of an adjacent State which has perhaps built similar bridges at public expense which are used freely by the citizens of the first State, an interstate question of a new order is raised. Such a case is now the subject of controversy between two of the States; and there may be many others in the future.

There would seem to be no more appropriate use of the Federal-aid appropriations than that which is presented by such structures—distinctly of interstate significance whether they lie at the border or in the interior of a State. It is possible, under the law, for the Federal Government to pay a full 50 per cent of the cost without regard to the amount so long as it is within the State's apportionment. By accepting the Federal assistance the State relieves its budget of half the total cost and the remainder, if financed with State bonds, will entail a smaller burden upon the citizens of the State than the tolls they would otherwise pay to a bridge building corporation. It is to be hoped, therefore, that as many as possible of such important bridges may be built in this way in the future; and in this connection it is gratifying to report that arrangements have now been made to finance in this way what is perhaps one of the four or five most important bridges in the country—the bridge over the Mississippi at Memphis.

FEDERAL AID DOES NOT CAUSE EXTRAVAGANT STATE EXPENDITURE

The total cost of the 9,417.3 miles of original construction and the 1,193 miles of stage construction completed during the year was $206,139,220.27, of which 90,294,106.76 was paid by the Federal Government. These expenditures were made over the period required to bring the above mileage to completion, approximately two years, and during the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal-aid funds was $87,754,534.57, as shown by States in Table 5. This is a reduction of approximately $8,000,000 below the disbursement of the preceding year, and further reduction may be expected in the future as accumulated balances are expended and the program of expenditure reaches the rate set by the annual authorization of $75,000,000 of the recent past and immediate future.

TABLE 5.—*Federal-aid disbursements to States, fiscal year 1926*

State	Federal-aid disbursement
Alabama	$1,966,619.02
Arizona	558,251.42
Arkansas	1,710,136.62
California	3,287,067.83
Colorado	1,468,873.84
Connecticut	179,493.71
Delaware	317,922.17
Florida	836,169.33
Georgia	2,546,473.57
Idaho	1,211,467.29
Illinois	2,061,553.20
Indiana	2,998,195.55
Iowa	1,179,173.37
Kansas	2,010,983.12
Kentucky	1,629,262.22
Louisiana	738,714.02
Maine	428,522.80
Maryland	982,038.88
Massachusetts	1,053,331.47
Michigan	2,798,228.48
Minnesota	2,294,445.91
Mississippi	1,554,835.53
Missouri	4,015,329.72
Montana	659,904.88
Nebraska	1,863,988.80
Nevada	1,453,240.19
New Hampshire	298,143.45
New Jersey	2,087,825.66
New Mexico	1,020,042.23
New York	4,664,644.52
North Carolina	3,082,882.17
North Dakota	925,094.42
Ohio	2,472,310.12
Oklahoma	2,887,622.14
Oregon	1,656,072.98
Pennsylvania	5,772,232.58
Rhode Island	285,490.94
South Carolina	1,810,458.38
South Dakota	1,828,659.29
Tennessee	2,364,696.15
Texas	5,284,156.01
Utah	1,081,703.45
Vermont	415,055.81
Virginia	2,514,371.36
Washington	1,430,361.90
West Virginia	1,096,945.39
Wisconsin	1,700,875.89
Wyoming	1,212,767.42
Hawaii	57,899.37
Total	87,754,534.57

As the annual highway expenditure of the country is in excess of a billion dollars, the Federal expenditure is not over 8 per cent of the total. And the fact that the percentage of interstate traffic on the roads of practically all States equals or exceeds that figure is evidence that, from the Federal point of view, the current rate of expenditure is not excessive, aside from all consideration of the general Federal

and interstate benefits derived from the resulting improvements. But the Federal-aid road work is a cooperative undertaking on the part of the Federal and State Governments in which the States are required to match in certain proportions the expenditures of the Federal Government. It is proper, therefore, to inquire whether in thus matching the contributions of the Government the States are induced to make expenditures for road improvement greater than they would make if the Federal aid were not offered.

That this is not the case is evidenced by the fact, as shown in Table 6, that in 1925 every State, without exception, made expenditures for road improvement in addition to those made for the Federal-aid roads, the total of such expenditures being $438,544,000, or approximately four times the amount spent to match the Federal aid. These are State expenditures only. They do not include the amounts spent by the counties independent of State control which, doubtless, equaled or exceeded those of the States.

TABLE 6.—*Approximate disbursements by State highway departments in excess of expenditures for Federal-aid roads, calendar year 1925*

State	State disbursements for other than Federal-aid roads	State	State disbursements for other than Federal-aid roads
Alabama	$6,917,000	Nebraska	$1,964,000
Arizona	1,263,000	Nevada	936,000
Arkansas	7,140,000	New Hampshire	3,227,000
California	11,891,000	New Jersey	15,540,000
Colorado	1,797,000	New Mexico	223,000
Connecticut	7,252,000	New York	33,869,000
Delaware	2,703,000	North Carolina	24,088,000
Florida	6,234,000	North Dakota	143,000
Georgia	2,502,000	Ohio	16,386,000
Idaho	1,857,000	Oklahoma	6,138,000
Illinois	30,676,000	Oregon	13,153,000
Indiana	8,718,000	Pennsylvania	44,294,000
Iowa	11,608,000	Rhode Island	2,326,000
Kansas	836,000	South Carolina	5,633,000
Kentucky	10,667,000	South Dakota	2,871,000
Louisiana	6,870,000	Tennessee	9,129,000
Maine	6,465,000	Texas	6,585,000
Maryland	10,485,000	Utah	2,374,000
Massachusetts	8,935,000	Vermont	2,678,000
Michigan	30,038,000	Virginia	8,172,000
Minnesota	13,062,000	Washington	5,446,000
Mississippi	1,265,000	West Virginia	14,059,000
Missouri	23,084,000	Wisconsin	4,885,000
Montana	357,000	Wyoming	1,803,000

There is no ground for belief that the effort to meet the Federal contribution is burdensome to the taxpayers of the States. The State funds required to match a Federal appropriation of $75,000,000 a year in the proportions required by the Federal law amount to $67,081,920. As shown by Table 7, the gross income of the States from motor vehicle license fees and gasoline taxes amounted in the calendar year 1925 to $405,467,756, a sum sufficient to match the Federal aid six times over, almost large enough, indeed, to cover the entire annual expenditure of the State highway departments; and the amount of this income from the motor vehicle is still increasing with the phenomenal growth of registration. These special taxes are paid by owners of motor vehicles, not grudgingly, but with entire willingness so long as they are used for road improvement, because it is generally recognized that the return in the form of reduced operating expense and improved highway service more than compensates the tax.

Table 7 follows.

TABLE 7.—*Comparison of State motor-vehicle revenues and funds required to match Federal appropriations*

State	State funds required to match Federal appropriation of $75,000,000	Gross income from motor-vehicle license fees and gasoline taxes, calendar year 1925
Alabama	$1,541,870	$4,651,931
Arizona [1]	403,800	1,261,543
Arkansas	1,264,164	6,100,360
California [1]	1,628,000	22,773,087
Colorado [1]	1,068,000	3,391,245
Connecticut	474,801	7,553,056
Delaware	365,625	1,022,781
Florida	892,878	11,303,135
Georgia	1,983,089	7,429,239
Idaho [1]	628,000	2,088,030
Illinois [2]	3,191,479	12,969,754
Indiana	1,938,693	12,302,712
Iowa	2,070,396	13,246,218
Kansas	2,074,360	7,515,284
Kentucky	1,411,607	6,821,622
Louisiana	997,262	5,739,588
Maine	685,140	3,450,483
Maryland	635,783	4,553,337
Massachusetts [2]	1,090,118	9,843,901
Michigan	2,225,227	22,762,080
Minnesota	2,124,151	13,608,774
Mississippi	1,291,960	4,024,274
Missouri	2,417,727	11,426,213
Montana [1]	1,193,000	1,589,963
Nebraska	1,581,969	6,130,260
Nevada [1]	132,000	527,902
New Hampshire	365,625	2,443,166
New Jersey [2]	935,082	10,515,323
New Mexico [1]	690,000	995,230
New York [2]	3,657,096	25,506,245
North Carolina	1,699,168	14,442,222
North Dakota	1,180,699	1,717,989
Ohio	2,789,588	22,157,181
Oklahoma [1]	1,415,000	9,720,089
Oregon [1]	710,000	8,279,297
Pennsylvania	3,360,123	30,279,770
Rhode Island	365,625	2,182,312
South Carolina	1,052,549	6,231,479
South Dakota [1]	965,000	4,292,710
Tennessee	1,622,985	6,468,834
Texas	4,415,715	18,119,715
Utah [1]	229,000	1,618,239
Vermont	365,625	1,999,418
Virginia	1,449,713	8,002,901
Washington [1]	941,000	8,000,838
West Virginia	797,295	5,540,986
Wisconsin	1,873,308	11,927,886
Wyoming [1]	525,000	939,154
Hawaii [3]	365,625	
Total	67,081,920	405,467,756

[1] States not on 50–50 basis on account of public lands and nontaxable Indian lands.
[2] No gasoline tax assessed.
[3] No tax data available.

As shown by the foregoing facts there is no reason to believe that the necessity of matching Federal aid has caused the States to incur a large bonded indebtedness. Twenty-four of the States have issued no bonds for highway purposes since Federal aid was initiated. The other 24 have incurred a total indebtedness of $604,410,600. In 13 of these the amount of the bonds issued has considerably exceeded the total of their Federal-aid apportionments, and can not, therefore, have been required to match the Federal contributions. Of the remaining 11 States, 3—Massachusetts, New York, and Rhode Island—are States of large resources, and it is not conceivable that they have needed to issue bonds to match the Federal aid. Two others—Louisiana and Nevada—have a negligible total indebtedness. The remaining 6 States are Colorado, Idaho, New Mexico, South Dakota, Utah, and Wyoming; and it is conceivable that their bond issues may have been necessary to provide funds with which to match the Federal aid offered to them; but their combined issues during the 10-year period amount to only $31,800,000, and they have received almost double that amount from the Federal Government.

FEDERAL-AID APPORTIONMENT CONSISTENT WITH TRAFFIC DEMAND

The Federal-aid appropriations are apportioned in accordance with a method prescribed by the law on the basis of the relative area and population of the several States and their total mileage of rural post roads and star routes. Although the method is somewhat arbitrary, it has been shown repeatedly to produce a result which is fairly consistent with the basic wealth and production of the several States. As these are the factors which, fundamentally, are the measures both of the need for highway improvement and the capacity to pay for it, there can be no reasonable doubt of the essential fairness of the distribution.

Viewed specifically from the standpoint of the traffic demand of the several groups of States, Table 8 shows that the apportionment per mile of the Federal-aid system to date is reasonably consistent with the traffic requirements as measured by the motor-vehicle registration per mile of the system. The largest potential traffic, i. e., the largest motor-vehicle registration per mile, is in the Middle Atlantic States, and this group of States, including New York, Pennsylvania, and New Jersey, is also shown to have received the largest apportionment of Federal aid in proportion to the mileage of the Federal-aid system within their borders. Next in order of potential traffic and also in the magnitude of the apportionment are the New England States; and a similarly consistent relation exists with respect to all other groups, with the exception of the East South Central and Mountain States, which are shown

to have received a somewhat disproportionate apportionment considered from the point of view of their potential traffic. The order of the several groups of States in Table 8 is very similar to their relative ranking on the basis of the mileage of high-type Federal-aid road construction as shown in Table 2, thus indicating that the Federal appropriations are being expended in a manner consistent with the requirements of the traffic.

TABLE 8.—*Apportionment of Federal aid per mile of Federal-aid highway system compared with motor-vehicle registration*

Group of States	Mileage of Federal-aid system approved to June 30, 1926	Federal-aid funds apportioned to States June 11, 1916, to June 30, 1926	Motor vehicles registered during 1925	Average Federal-aid apportionment per mile of system	Motor-vehicle registration per mile of system
	Miles				
Middle Atlantic	10,306.8	$73,851,396	3,536,570	$7,165	343
New England	5,799.7	30,012,803	1,290,151	5,175	223
East North Central	26,310.1	111,549,529	4,918,383	4,240	187
Pacific	10,296.1	43,097,938	1,985,536	4,186	193
East South Central	14,429.8	54,970,873	878,115	3,810	61
South Atlantic	21,429.3	81,288,777	1,817,890	3,793	85
Mountain	21,615.3	80,080,227	692,779	3,705	32
West South Central	24,328.0	77,544,430	1,790,017	3,187	74
West North Central	47,619.7	117,878,874	2,941,814	2,475	62
All States	182,134.8	[1] 670,274,847	19,851,255	3,680	109

[1] Including the apportionment of $1,100,153 to Hawaii the total apportionment up to June 30, 1926, was $671,375,000.

SUMMARY OF FEDERAL-AID ROAD WORK BY STATES

The progress made in each of the States during the year and the results of the 10 years of Federal-aid road construction are set forth in the following condensed summary for each State.

ALABAMA

The Federal-aid highway system in Alabama includes 3,872 miles, of which 1,415.7 miles have been improved with Federal aid. Of the improved mileage, 262 miles were added during the year, and 89.9 miles were under construction.

The mileage improved with Federal aid consists of 28.3 miles of graded and drained earth roads, 417.5 miles of sand-clay, 768.6 miles of gravel, 6 miles of water-bound macadam, 58.8 miles of bituminous macadam, 80.8 miles of bituminous concrete, and 52.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of the roads completed during the year was $4,288,712.99, of which the Federal share was $1,831,731.14. The disbursement of Federal funds to the State was $1,966,619.02. This added to the disbursements made during previous years and subtracted from the State's total apportionment of $14,349,455, leaves a balance of $4,430,272.52 of unexpended funds to the credit of the State.

ARIZONA

The Federal-aid highway system includes 1,498 miles, of which 767.1 miles have been improved with Federal aid. Of the improved mileage 96.6 miles were added during the year. At the close of the year 44.1 miles were under construction and 12.2 miles were approved but not yet under construction.

The mileage improved with Federal aid consists of 92.4 miles of graded and drained earth roads, 122.3 miles of sand-clay, 404.8 miles of gravel, 14.2 miles of water-bound macadam, 22.7 miles of bituminous concrete, and 108.6 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of the roads completed was $1,378,605.07, of which the Federal share was $885,678.50. The disbursement of Federal funds to the State was $558,251.42. This added to the disbursements made during previous years and substracted from the State's total apportionment of $9,617,249, leaves a balance of $3,358,108.81 of unexpended funds to the credit of the State.

ARKANSAS

The Federal-aid highway system includes 5,007 miles, of which 1,418.5 miles have been improved with Federal aid. Of the improved mileage 281.6 miles were added during the year. At the close of the year 213.3 miles were under construction and 31.1 miles were approved.

The mileage improved with Federal aid consists of 3.1 miles of sand-clay, 919.2 miles of gravel, 48.2 miles of water-bound macadam, 84.1 miles of bituminous macadam, 248.4 miles of bituminous concrete, and 114.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of the roads completed was $4,375,795.99, of which the Federal share was $2,317,678.87. The disbursement of Federal funds to the State was $1,710,136.62. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $11,605,804, leaves a balance of $2,503,265.69 of unexpended funds to the credit of the State.

CALIFORNIA

The Federal-aid highway system includes 4,574.4 miles, of which 1,169.7 miles have been improved with Federal aid. Of the improved mileage, 222.8 miles were added during the year. At the close of the year 208.2 miles were under construction and 18.2 miles were approved.

The mileage improved with Federal aid consists of 276.9 miles of graded and drained earth roads, 280.4 miles of gravel, 18.1 miles of water-bound macadam, 55.5 miles of bituminous macadam, 67.3 miles of bituminous concrete, and 468.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.6 miles.

The total cost of the roads completed, including 7.1 miles of stage construction, was $5,727,131.79, of which the Federal share was $2,752,692.79. The disbursement of Federal funds to the State was $3,287,067.83. This, added to the disbursements made during previous years and substracted from the State's total apportionment of $22,072,815, leaves a balance of $5,952,659.70 of unexpended funds to the credit of the State.

COLORADO

The Federal-aid highway system includes 3,332 miles, of which 797 miles have been improved with Federal aid Of the improved mileage, 84.5 miles were added during the year. At the close of the year 162.5 miles were under construction and 21.8 miles were approved.

The mileage improved with Federal aid consists of 172.5 miles of graded and drained earth roads, 76.8 miles of sand-clay, 352.7 miles of gravel, 5.9 miles of bituminous concrete, and 184.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 4.4 miles.

The total cost of the roads completed, including 1.9 miles of stage construction, was $1,923,572.30, of which the Federal share was $966,142.48. The disbursement of Federal funds to the State was $1,468,873.84. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $12,325,812, leaves a balance of $4,196,323.82 of unexpended funds to the credit of the State.

CONNECTICUT

The Federal-aid highway system includes 835.4 miles, of which 127.1 miles have been improved with Federal aid. Of the improved mileage 8.7 miles were added during the year. At the close of the year 38 miles were under construction and 9.9 miles were approved.

The mileage improved with Federal aid consists of 8.8 miles of water-bound macadam, 27 miles of bituminous macadam, and 91.3 miles of Portland cement concrete.

The total cost of the roads completed was $395,689.66, of which the Federal share was $136,570. The disbursement of Federal funds to the State was $179,493.71. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $4,333,681, leaves a balance of $1,980,818.25 of unexpended funds to the credit of the State.

DELAWARE

The Federal-aid highway system includes 385.2 miles, of which 124.3 miles have been improved with Federal aid. Of the improved mileage 8.6 miles were added during the year. At the close of the year 28.2 miles were under construction and 15.7 miles were approved.

The mileage improved with Federal aid consists of 117.9 miles of Portland cement concrete and 6.2 miles of brick, in addition to which there are bridges with a total length of 0.2 mile.

The total cost of the roads completed was $269,509.49, of which the Federal share was $127,843.85. The disbursement of Federal funds to the State was

$317,922.17. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $2,474,058, leaves a balance of $556,979.74 of unexpended funds to the credit of the State.

FLORIDA

The Federal-aid highway system includes 1,926 miles, of which 249.7 miles have been improved with Federal aid. Of the improved mileage 36.9 miles were added during the year. At the close of the year 162.9 miles were under construction.

The mileage improved with Federal aid consists of 11.8 miles of graded and drained earth roads, 34.1 miles of sand-clay, 13.6 miles of water-bound macadam, 72.6 miles of bituminous macadam, 23.3 miles of bituminous concrete, 81.7 miles of Portland cement concrete, and 10.1 miles of brick, in addition to which there are bridges with a total length of 2.6 miles.

The total cost of the roads completed was $1,700,890.98, of which the Federal share was $818,937.01. The disbursement of Federal funds to the State was $836,169.33. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,084,954, leaves a balance of $3,235,949.42 unexpended funds to the credit of the State.

GEORGIA

The Federal-aid highway system includes 5,558.4 miles, of which 1,975.5 miles have been improved with Federal aid. Of the improved mileage 322.7 miles were added during the year. At the close of the year 475.4 miles were under construction and 28.3 miles were approved.

The mileage improved with Federal aid consists of 96.2 miles of graded and drained earth roads, 1,194.9 miles of sand-clay, 345.7 miles of gravel, 41.7 miles of water-bound macadam, 95.9 miles of bituminous macadam, 15.9 miles of bituminous concrete, 161.9 miles of Portland cement concrete, and 0.5 mile of brick, in addition to which there are bridges with a total length of 23.1 miles.

The total cost of the roads completed, including 20.4 miles of stage construction, was $5,141,532.68, of which the Federal share was $2,504,419.51. The disbursement of Federal funds to the State was $2,546,473.57. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $18,431,953, leaves a balance of $2,991,838.09 unexpended funds to the credit of the State.

IDAHO

The Federal-aid highway system includes 2,768.6 miles, of which 773.7 miles have been improved with Federal aid. Of the improved mileage 133.8 miles were added during the year. At the close of the year 113.5 miles were under construction and 72.5 miles were approved.

The mileage improved with Federal aid consists of 165.6 miles of graded and drained earth roads, 18.6 miles of sand-clay, 514 miles of gravel, 4.3 miles of water-bound macadam, 37.6 miles of bituminous concrete, and 32.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.1 miles.

The total cost of the roads completed, including 36 miles of stage construction, was $2,081,356.55, of which the Federal share was $1,320,858.71. The disbursement of Federal funds to the State was $1,211,467.29. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,559,627, leaves a balance of $1,870,582.13 of unexpended funds to the credit of the State.

ILLINOIS

The Federal-aid highway system includes 5,002.2 miles, of which 1,467.1 miles have been improved with Federal aid. Of the improved mileage 182.4 miles were added during the year. At the close of the year 124.4 miles were under construction and 24 miles were approved.

The mileage improved with Federal aid consists 112.3 miles of graded and drained earth roads, 3.3 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1,315.9 miles of Portland cement concrete, and 25.8 miles of brick, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of the roads completed, including 0.6 mile of stage construction, was $5,177,738.18, of which the Federal share was $2,532,879.71. The disbursement of Federal funds to the State was $2,061,553.20. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $29,832,198, leaves a balance of $7,285,381.97 of unexpended funds to the credit of the State.

INDIANA

The Federal-aid highway system includes 4,679 miles, of which 687.2 miles have been improved with Federal aid. Of the improved mileage 157.2 miles were added during the year. At

the close of the year 275.1 miles were under construction and 51.7 miles were approved.

The mileage improved with Federal aid consists of 25.6 miles of graded and drained earth roads, 33.5 miles of gravel, 17 miles of bituminous macadam, 12 miles of bituminous concrete, and 597.6 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of the roads completed was $5,432,841.65, of which the Federal share was $2,584,668.72. The disbursement of Federal funds to the State was $2,998,195.55. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $18,204,355, leaves a balance of $4,699,325.92 of unexpended funds to the credit of the State.

IOWA

The Federal-aid highway system includes 7,212 miles, of which 2,177 miles have been improved with Federal aid. Of the improved mileage 138.6 miles were added during the year. At the close of the year 586.7 miles were under construction and 146.8 miles were approved.

The mileage improved with Federal aid consists of 1,303.4 miles of graded and drained earth roads, 425.5 miles of gravel, 425.9 miles of Portland cement concrete, and 22 miles of brick, in addition to which there are bridges with a total length of 0.3 mile.

The total cost of the roads completed, including 12.4 miles of stage construction, was $2,589,254.14, of which the Federal share was $1,170,140.16. The disbursement of Federal funds to the State was $1,179,173.37. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $19,485,563, leaves a balance of $5,683,720.65 of unexpended funds to the credit of the State.

KANSAS

The Federal-aid highway system includes 7,892 miles, of which 1,263.6 miles have been improved with Federal aid. Of the improved mileage 269.1 miles were added during the year. At the close of the year 548.9 miles were under construction and 129.9 miles were approved.

The mileage improved with Federal aid consists of 313 miles of graded and drained earth roads, 112.2 miles of sand-clay, 180.8 miles of gravel, 4.5 miles of water-bound macadam, 84.6 miles of bituminous macadam, 3.5 miles of bituminous concrete, 439.2 miles of Portland cement concrete, and 123 miles of brick, in addition to which there are bridges with a total length of 2.5 miles.

The total cost of the roads completed, including 19.6 miles of stage construction, was $4,023,851.60, of which the Federal share was $2,034,853.94. The disbursement of Federal funds to the State was $2,010,983.12. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $19,464,411, leaves a balance $4,791,623.07 of unexpended funds to the credit of the State.

KENTUCKY

The Federal-aid highway system includes 3,701 miles, of which 787.4 miles have been improved with Federal aid. Of the improved mileage 188.8 miles were added during the year. At the close of the year 250.9 miles were under construction and 3.6 miles were approved.

The mileage improved with Federal aid consists of 388.9 miles of graded and drained earth roads, 118.9 miles of gravel, 41.4 miles of water-bound macadam, 139.8 miles of bituminous macadam, 94.5 miles of Portland cement concrete, and 3.9 miles of brick, in addition to which there are bridges with a total length of 0.2 mile.

The total cost of the roads completed, including 34 miles of stage construction, was $5,919,328.90, of which the Federal share was $2,252,781.48. The disbursement of Federal funds to the State was $1,629,262.22. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $13,212,809, leaves a balance of $3,302,647.39 of unexpended funds to the credit of the State.

LOUISIANA

The Federal-aid highway system includes 2,664 miles, of which 1,069.8 miles have been improved with Federal aid. Of the improved mileage 44.3 miles were added during the year. At the close of the year 147.4 miles were under construction and 29.8 miles were approved.

The mileage improved with Federal aid consists of 3.4 miles of graded and drained earth roads, 1,037.1 miles of gravel, 3.2 miles of water-bound macadam, 9.5 miles of bituminous macadam, 10.4 miles of bituminous concrete, and 3.6 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of the roads completed was $908,749.55, of which the Federal

share was $362,623.35. The disbursement of Federal funds to the State was $738,714.02. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $9,272,408, leaves a balance of $2,238,441.66 of unexpended funds to the credit of the State.

MAINE

The Federal-aid highway system includes 1,393.5 miles, of which 303.6 miles have been improved with Federal aid. Of the improved mileage 15.6 miles were added during the year. At the close of the year 67.3 miles were under construction and 45.6 miles were approved.

The mileage improved with Federal aid consists of 126.7 miles of gravel, 137.4 miles of bituminous macadam, and 39.3 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.2 mile.

The total cost of the roads completed was $388,599.74, of which the Federal share was $192,580.02. The disbursement of Federal funds to the State was $428,522.80. This, added to the disbursement made during previous years and subtracted from the State's total apportionment of $6,464,828, leaves a balance of $1,958,707.32 of unexpended funds to the credit of the State.

MARYLAND

The Federal-aid highway system includes 1,479.2 miles, of which 423.3 miles have been improved with Federal aid. Of the improved mileage 103.3 miles were added during the year. At the close of the year 30.7 miles were under construction and 57.7 miles were approved.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of gravel, 0.1 mile of water-bound macadam, 106.9 miles of bituminous macadam, 12.3 miles of bituminous concrete, and 268 miles of Portland cement concrete.

The total cost of the roads completed was $1,985,590.44, of which the Federal share was $901,945.32. The disbursement of Federal funds to the State was $982,038.88. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $5,925,057, leaves a balance of $778,960.03 of unexpended funds to the credit of the State.

MASSACHUSETTS

The Federal-aid highway system includes 1,308 miles, of which 385.7 miles have been improved with Federal aid. Of the improved mileage 56.8 miles were added during the year. At the close of the year 35.4 miles were under construction and 21.1 miles were approved.

The mileage improved with Federal aid consists of 3.3 miles of water-bound macadam, 199.2 miles of bituminous macadam, 36.8 miles of bituminous concrete, and 143.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.5 miles.

The total cost of the roads completed was $3,717,850.99, of which the Federal share was 932,863.07. The disbursement of Federal funds to the State was $1,053,331.47. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,108,726, leaves a balance of $3,314,597.38 of unexpended funds to the credit of the State.

MICHIGAN

The Federal-aid highway system includes 5,235 miles, of which 995.8 miles have been improved with Federal aid. Of the improved mileage 134.1 miles were added during the year. At the close of the year 213.7 miles were under construction and 11.6 miles were approved.

The mileage improved with Federal aid consists of 29.2 miles of graded and drained earth roads, 316.1 miles of gravel, 18.9 miles of water-bound macadam, 10.4 miles of bituminous macadam, 73.4 miles of bituminous concrete, 547.4 miles of Portland cement concrete, and 0.4 mile of brick.

The total cost of the roads completed, including 3.9 miles of stage construction, was $4,599,169.26, of which the Federal share was $1,985,509.96. The disbursement of Federal funds to the State was $2,798,228.48. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $20,342,365, leaves a balance of $5,679,010.31 of unexpended funds to the credit of the State.

MINNESOTA

The Federal-aid highway system includes 6,849.6 miles, of which 3,249.2 miles have been improved with Federal aid. Of the improved mileage 528 miles were added during the year. At the close of the year 524 miles were under construction and 11.1 miles were approved.

The mileage improved with Federal aid consists of 379 miles of graded and drained earth roads, 6.2 miles of sand-clay, 2,500 miles of gravel, 27.9 miles of bituminous concrete, and 335.5 miles

of Portland cement concrete, in addition to which there are bridges with a total length of 0.6 mile.

The total cost of the roads completed, including 174.9 miles of stage construction, was $7,435,078.06, of which the Federal share was $3,173,974.52. The disbursement of Federal funds to the State was $2,294,445.91. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $19,591,780, leaves a balance of $2,658,903.46 of unexpended funds to the credit of the State.

MISSISSIPPI

The Federal-aid highway system includes 3,604 miles, of which 1,158.9 miles have been improved with Federal aid. Of the improved mileage 286.4 miles were added during the year. At the close of the year 330.7 miles were under construction and 95.1 miles were approved.

The mileage improved with Federal aid consists of 136.4 miles of graded and drained earth roads, 20.6 miles of sand-clay, 873.6 miles of gravel, 11.1 miles of water-bound macadam, 1 mile of bituminous macadam, 9.2 miles of bituminous concrete, 97.1 miles of Portland cement concrete, and 9.2 miles of brick, in addition to which there are bridges with a total length of 0.5 mile.

The total cost of the roads completed, including 36.6 miles of stage construction, was $4,340,617.88, of which the Federal share was $2,169,238.93. The disbursement of Federal funds to the State was $1,554,835.53. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $12,128,018, leaves a balance of $3,007,839.31 of unexpended funds to the credit of the State.

MISSOURI

The Federal-aid highway system includes 7,530 miles, of which 1,795.7 miles have been improved with Federal aid. Of the improved mileage 446.1 miles were added during the year. At the close of the year 311.1 miles were under construction and 23.1 miles were approved.

The mileage improved with Federal aid consists of 326.8 miles of graded and drained earth roads, 842.9 miles of gravel, 13.4 miles of water-bound macadam, 50.8 miles of bituminous macadam, 17.7 miles of bituminous concrete, 528.2 miles of Portland cement concrete, and 8.5 miles of brick, in addition to which there are bridges with a total length of 7.4 miles.

The total cost of the roads completed, including 28.8 miles of stage construction, was $15,050,108.77, of which the Federal share was $6,583,420.13. The disbursement of Federal funds to the State was $4,015,329.72. This, added to the disbursements made during the previous years and subtracted from the State's total apportionment of $22,786,436, leaves a balance of $5,989,361.91 of unexpended funds to the credit of the State.

MONTANA

The Federal-aid highway system includes 4,661 miles, of which 1,071.5 miles have been improved with Federal aid. Of the improved mileage 133.8 miles were added during the year. At the close of the year 116.1 miles were under construction and 145.7 miles were approved.

The mileage improved with Federal aid consists of 214.2 miles of graded and drained earth roads, 5.6 miles of sand-clay, 792.7 miles of gravel, 16 miles of water-bound macadam, 6.9 miles of bituminous macadam, 2.8 miles of bituminous concrete, and 31.3 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.3 miles.

The total cost of the roads completed was $1,540, 284.08, of which the Federal share was $1,174,701.33. The disbursement of Federal funds to the State was $659,904.88. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $13,424,885, leaves a balance of $6,542,069.51 of unexpended funds to the credit of the State.

NEBRASKA

The Federal-aid highway system includes 5,569.1 miles, of which 2,021.2 miles have been improved with Federal aid. Of the improved mileage 146.5 miles were added during the year. At the close of the year 1,099.2 miles were under construction and 94 miles were approved.

The mileage improved with Federal aid consists of 1,213.9 miles of graded and drained earth roads, 169.2 miles of sand-clay, 559.2 miles of gravel, 10.1 miles of bituminous concrete, 46.5 miles of Portland cement concrete, and 18.6 miles of brick, in addition to which there are bridges with a total length of 3.2 miles.

The total cost of the roads completed, including 209.4 miles of stage construction, was $1,412,172.43, of which the Federal share was $682,658.91. The disbursement of Federal funds to the State was $1,863,988.80. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $14,635,235, leaves a balance of

$5,771,303.41 of unexpended funds to the credit of the State.

NEVADA

The Federal-aid highway system includes 1,398 miles, of which 710.1 miles have been improved with Federal aid. Of the improved mileage 282.3 miles were added during the year. At the close of the year 174.8 miles were under construction and 42.8 miles were approved.

The mileage improved with Federal aid consists of 53.8 miles of graded and drained earth roads, 26.4 miles of sand-clay, 555.3 miles of gravel, 10.2 miles of water-bound macadam, 15.6 miles of bituminous macadam, 2 miles of bituminous concrete, and 44.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of the roads completed, including 5.1 miles of stage construction, was $3,280,931.39, of which the Federal share was $2,634,795.38. The disbursement of Federal funds to the State was $1,453,240.19. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,795,215, leaves a balance of $1,301,853.81 of unexpended funds to the credit of the State.

NEW HAMPSHIRE

The Federal-aid highway system includes 977.4 miles, of which 244.6 miles have been improved with Federal aid. Of the improved mileage 29.6 miles were added during the year. At the close of the year 19 miles were under construction and 6.9 miles were approved.

The mileage improved with Federal aid consists of 96.5 miles of gravel, 46.5 miles of water-bound macadam, 63.9 miles of bituminous macadam, 30 miles of bituminous concrete, and 5.2 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.4 miles.

The total cost of the roads completed was $884,824.61, of which the Federal share was $424,791.20. The disbursement of Federal funds to the State was $298,143.45. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $3,169,492, leaves a balance of $687,878.77 of unexpended funds to the credit of the State.

NEW JERSEY

The Federal-aid highway system includes 1,198.3 miles, of which 307.9 miles have been improved with Federal aid. Of the improved mileage 78.3 miles were added during the year. At the close of the year 14 miles were under construction and 10 miles were approved.

The mileage improved with Federal aid consists of 1.6 miles of graded and drained earth roads, 0.8 mile of sand-clay, 0.5 mile of gravel, 21.9 miles of bituminous concrete, and 279.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.7 mile.

The total cost of the roads completed was $4,612,641.22, of which the Federal share was $1,347,757.63. The disbursement of Federal funds to the State was $2,087,825.66. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,467,420, leaves a balance of $1,704,648.21 of unexpended funds to the credit of the State.

NEW MEXICO

The Federal-aid highway system includes 3,298 miles, of which 1,490.5 miles have been improved with Federal aid. Of the improved mileage 137.5 miles were added during the year. At the close of the year 36.9 miles were under construction and 34 miles were approved.

The mileage improved with Federal aid consists of 225.8 miles of graded and drained earth roads, 5.1 miles of sand-clay, 1,181.2 miles of gravel, 0.7 mile of bituminous concrete, and 76.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.3 miles.

The total cost of the roads completed, including 15.8 miles of stage construction, was $1,483,178.56, of which the Federal share was $908,377.49. The disbursement of Federal funds to the State was $1,020,042.23. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,972,386, leaves a balance of $3,097,525.07 of unexpended funds to the credit of the State.

NEW YORK

The Federal-aid highway system includes 5,018 miles, of which 1,231.8 miles have been improved with Federal aid. Of the improved mileage 259.8 miles were added during the year. At the close of the year 532.6 miles were under construction and 136.6 miles were approved.

The mileage improved with Federal aid consists of 8.6 miles of gravel, 320.7 miles of bituminous macadam, 4.8 miles of bituminous concrete, 895.6 miles of Portland cement concrete, and 0.7 mile of brick, in addition to which there

are bridges with a total length of 1.5 miles.

The total cost of the roads completed was $10,162,510, of which the Federal share was $3,791,280.66. The disbursement of Federal funds to the State was $4,664,644.52. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $34,045,195, leaves a balance of $13,367,889.20 of unexpended funds to the credit of the State.

NORTH CAROLINA

The Federal-aid highway system includes 3,781 miles, of which 1,343.1 miles have been improved with Federal aid. Of the improved mileage 164.6 miles were added during the year. At the close of the year 105 miles were under construction and 26.1 miles were approved.

The mileage improved with Federal aid consists of 80.7 miles of graded and drained earth roads, 520.6 miles of sand-clay, 85.8 miles of gravel, 19.6 miles of water-bound macadam, 38 miles of bituminous macadam, 228.6 miles of bituminous concrete, and 367.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.9 miles.

The total cost of the roads completed, including 61 miles of stage construction, was $7,385,531.70, of which the Federal share was $3,056,122.87. The disbursement of Federal funds to the State was $3,082,882.17. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $15,717,206, leaves a balance of $2,842,516.78 of unexpended funds to the credit of the State.

NORTH DAKOTA

The Federal-aid highway system includes 6,836 miles, of which 2,275.7 miles have been improved with Federal aid. Of the improved mileage 260.4 miles were added during the year. At the close of the year 650.7 miles were under construction and 388.8 miles were approved.

The mileage improved with Federal aid consists of 1,348.4 miles of graded and drained earth roads, 1.5 miles of sand-clay, 919.6 miles of gravel, 1.2 miles of bituminous concrete, and 3 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of the roads completed, including 318.2 miles of stage construction, was $1,780,585.28, of which the Federal share was $907,695.08. The disbursement of Federal funds to the State was $925,094.42. This, added to the disbursements made during previous years and subtracted from the State's apportionment of $10,748,659, leaves a balance of $3,947,950.29 of unexpended funds to the credit of the State.

OHIO

The Federal-aid highway system includes 5,900.5 miles, of which 1,422.6 miles have been improved with Federal aid. Of the improved mileage 197 miles were added during the year. At the close of the year 295 miles were under construction and 85.8 miles were approved.

The mileage improved with Federal aid consists of 47 miles of graded and drained earth roads, 82.6 miles of water-bound macadam, 303.1 miles of bituminous macadam, 88.1 miles of bituminous concrete, 454.5 miles of Portland cement concrete, and 447 miles of brick, in addition to which there are bridges with a total length of 0.1 mile.

The total cost of the roads completed was $6,611,677.60, of which the Federal share was $2,415,369.63. The disbursement of Federal funds to the State was $2,472,310.12. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $25,731,796, leaves a balance of $6,559,239.10 of unexpended funds to the credit of the State.

OKLAHOMA

The Federal-aid highway system includes 5,528 miles of which 1,201.5 miles have been improved with Federal aid. Of the improved mileage 291.3 miles were added during the year. At the close of the year 74.8 miles were under construction and 64.7 miles were approved.

The mileage improved with Federal aid consists of 114.3 miles of graded and drained earth roads, 2.3 miles of sand-clay, 595.7 miles of gravel, 6.3 miles of water-bound macadam, 8.4 miles of bituminous macadam, 64.5 miles of bituminous concrete, 391.7 miles of Portland cement concrete, and 8.9 miles of brick, in addition to which there are bridges with a total length of 9.4 miles.

The total cost of the roads completed, including 2 miles of stage construction, was $6,508,352.72, of which the Federal share was $3,063,016.96. The disbursement of Federal funds to the State was $2,887,622.14. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $16,059,787, leaves a balance of $2,-

399,374.70 of unexpended funds to the credit of the State.

OREGON

The Federal-aid highway system includes 2,814 miles, of which 961.6 miles have been improved with Federal aid. Of the improved mileage 132.4 miles were added during the year. At the close of the year 103.9 miles were under construction and 22 miles were approved.

The mileage improved with Federal aid consists of 132.6 miles of graded and drained earth roads, 656.1 miles of gravel, 25.6 miles of water-bound macadam, 0.8 mile of bituminous macadam, 52.9 miles of bituminous concrete, and 91.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.3 miles.

The total cost of the roads completed, including 7.7 miles of stage construction, was $2,616,671.11, of which the Federal share was $1,434,973.97. The disbursement of Federal funds to the State was $1,656,072.98. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,879,347, leaves a balance of $1,431,330.61 of unexpended funds to the credit of the State.

PENNSYLVANIA

The Federal-aid highway system includes 4,090.5 miles, of which 1,435.2 miles have been improved with Federal aid. Of the improved mileage 447.6 miles were added during the year. At the close of the year 283.3 miles were under construction and 57.4 miles were approved.

The mileage improved with Federal aid consists of 32.9 miles of graded and drained earth roads, 3.4 miles of gravel, 7.8 miles of bituminous macadam, 101.1 miles of bituminous concrete, 1,266.9 miles of Portland cement concrete, and 26.4 miles of brick.

The total cost of the roads completed was $23,774,022.81, of which the Federal share was $6,574,796.61. The disbursement of Federal funds to the State was $5,772,232.58. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $31,338,781, leaves a balance of $5,910,862.03 of unexpended funds to the credit of the State.

RHODE ISLAND

The Federal-aid highway system includes 242.4 miles, of which 94.3 miles have been improved with Federal aid. Of the improved mileage 23.5 miles were added during the year. At the close of the year 20.9 miles were under construction and 8.3 miles were approved.

The mileage improved with Federal aid consists of 1.9 miles of water-bound macadam, 16.5 miles of bituminous macadam, 38.3 miles of bituminous concrete, and 37.5 miles of Portland cement concrete.

The total cost of the roads completed was $1,165,514.70, of which the Federal share was $390,685.01. The disbursement of Federal funds to the State was $285,490.94. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $2,667,569, leaves a balance of $1,108,739.94 of unexpended funds to the credit of the State.

SOUTH CAROLINA

The Federal-aid highway system includes 3,230 miles, of which 1,536.9 miles have been improved with Federal aid. Of the improved mileage 225.8 miles were added during the year. At the close of the year 185.9 miles were under construction and 19.2 miles were approved.

The mileage improved with Federal aid consists of 34.2 miles of graded and drained earth roads, 1,232.7 miles of sand-clay, 114.5 miles of gravel, 6 miles of water-bound macadam, 3 miles of bituminous macadam, 63.5 miles of bituminous concrete, 75 miles of Portland cement concrete, and 0.2 mile of brick, in addition to which there are bridges with a total length of 7.8 miles.

The total cost of the roads completed, including 14.2 miles of stage construction, was $4,750,910.07, of which the Federal share was $2,178,552.57. The disbursement of Federal funds to the State was $1,810,458.38. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $9,801,524, leaves a balance of $1,553,790.08 of unexpended funds to the credit of the State.

SOUTH DAKOTA

The Federal-aid highway system includes 5,731 miles, of which 2,345.8 miles have been improved with Federal aid. Of the improved mileage 765.9 miles were added during the year. At the close of the year 468.7 miles were under construction and 119.8 miles were approved.

The mileage improved with Federal aid consists of 481.1 miles of graded and drained earth roads, 18.2 miles of sand-clay, 1,843.3 miles of gravel, and 1.2 miles of Portland cement concrete,

in addition to which there are bridges with a total length of 1.9 miles.

The total cost of the roads completed, including 47.4 miles of stage construction, was $4,915,754.67, of which the Federal share was $2,368,152.66. The disbursement of Federal funds to the States was $1,828,659.29. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $11,166,790, leaves a balance of $1,796,628.42 of unexpended funds to the credit of the State.

TENNESSEE

The Federal-aid highway system includes 3,252.8 miles, of which 835.3 miles have been improved with Federal aid. Of the improved mileage 238.8 miles were added during the year. At the close of the year 193.1 miles were under construction and 24.6 miles were approved.

The mileage improved with Federal aid consists of 140.6 miles of graded and drained earth roads, 117 miles of gravel, 52.3 miles of water-bound macadam, 401.8 miles of bituminous macadam, 21.9 miles of bituminous concrete, and 100.3 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of the roads completed was $6,206,668.39, of which the Federal share was $2,691,356.46. The disbursement of Federal funds to the State was $2,364,696.15. This, added to the disbursement made during previous years and subtracted from the State's total apportionment of $15,280,591, leaves a balance of $3,203,506.19 of unexpended funds to the credit of the State.

TEXAS

The Federal-aid highway system includes 11,129 miles, of which 5,055.8 miles have been improved with Federal aid. Of the improved mileage 723.5 miles were added during the year. At the close of the year 771.8 miles were under construction and 61.4 miles were approved.

The mileage improved with Federal aid consists of 672.7 miles of graded and drained earth roads, 83.9 miles of sand-clay, 2,862.6 miles of gravel, 476.9 miles of water-bound macadam, 449.7 miles of bituminous macadam, 121.7 miles of bituminous concrete, 351.7 miles of Portland cement concrete, and 29.2 miles of brick, in addition to which there are bridges with a total length of 6.9 miles.

The total cost of the roads completed, including 41.3 miles of stage construction, was $9,403,940.27, of which the Federal share was $4,348,097.85. The disbursement of Federal funds to the State was $5,284,156.01. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $40,606,431, leaves a balance of $9,195,341.92 of unexpended funds to the credit of the State.

UTAH

The Federal-aid highway system includes 1,588 miles, of which 622.6 miles have been improved with Federal aid. Of the improved mileage 135.2 miles were added during the year. At the close of the year 77.8 miles were under construction and 49.4 miles were approved.

The mileage improved with Federal aid consists of 94.2 miles of graded and drained earth roads, 41.7 miles of sand-clay, 373.7 miles of gravel, 9.3 miles of water-bound macadam, 0.7 mile of bituminous macadam, 9.9 miles of bituminous concrete, and 91.6 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of the roads completed was $1,705,348.27, of which the Federal share was $1,185,427.86. The disbursement of Federal funds to the State was $1,081,703.45. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $7,818,779 leaves a balance of $1,790,016.98 of unexpended funds to the credit of the State.

VERMONT

The Federal-aid highway system includes 1,043 miles, of which 135.2 miles have been improved with Federal aid. Of the improved mileage 27.2 miles were added during the year. At the close of the year 33.9 miles were under construction and 1.5 miles were approved.

The mileage improved with Federal aid consists of 87.1 miles of gravel, 3.4 miles of water-bound macadam, 25 miles of bituminous macadam, and 16.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.7 miles.

The total cost of the roads completed was $1,239,157.62, of which the Federal share was $565,771.50. The disbursement of Federal funds to the State was $415,055.81. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $3,268,507, leaves a balance of $1,107,116.53 of unexpended funds to the credit of the State.

VIRGINIA

The Federal-aid highway system includes 3,075. 5 miles, of which 1,050.1 miles have been improved with Federal aid. Of the improved mileage 190.5 miles were added during the year. At the close of the year 141.1 miles were under construction and 10.9 miles were approved.

The mileage improved with Federal aid consists of 51.7 miles of graded and drained earth roads, 202.1 miles of sand-clay, 113.9 miles of gravel, 108.5 miles of water-bound macadam, 249.1 miles of bituminous macadam, 10.6 miles of bituminous concrete, and 312.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of the roads completed was $5,097,604.77, of which the Federal share was $2,302,948.28. The disbursement of Federal funds to the State was $2,514,371.36. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $13,501,-514, leaves a balance of $2,100,408.27 of unexpended funds to the credit of the State.

WASHINGTON

The Federal-aid highway system includes 2,907.7 miles, of which 668.6 miles have been improved with Federal aid. Of the improved mileage 116.7 miles were added during the year. At the close of the year 41.1 miles were under construction and 45.3 miles were approved.

The mileage improved with Federal aid consists of 108.8 miles of graded and drained earth roads, 311.3 miles of gravel, and 246.4 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of the roads completed, including 3.7 miles of stage construction, was $2,590,118.96, of which the Federal share was $1,120,697.59. The disbursement of Federal funds to the State was $1,430,361.90. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,145,-776, leaves a balance of $1,807,776.23 of unexpended funds to the credit of the State.

WEST VIRGINIA

The Federal-aid highway system includes 1,994 miles, of which 414.5 miles have been improved with Federal aid. Of the improved mileage 78.6 miles were added during the year. At the close of the year 115.5 miles were under construction and 40.3 miles were approved.

The mileage improved with Federal aid consists of 165.4 miles of graded and drained earth roads, 5.6 miles of sand-clay, 18.3 miles of gravel, 4.9 miles of water-bound macadam, 101.9 miles of bituminous macadam, 16.3 miles of bituminous concrete, 90.2 miles of Portland cement concrete, and 11.4 miles of brick, in addition to which there are bridges with a total length of 0.5 mile.

The total cost of the roads completed, including 13 miles of stage construction, was $2,731,548.14, of which the Federal share was $1,169,766.23. The disbursement of Federal funds to the State was $1,096,945.39. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $7,352,511, leaves a balance of $1,886,867.19 of unexpended funds to the credit of the State.

WISCONSIN

The Federal-aid highway system includes 5,493.4 miles, of which 1,619.1 miles have been improved with Federal aid. Of the improved mileage 134.5 miles were added during the year. At the close of the year 286.4 miles were under construction and 102.8 miles were approved.

The mileage improved with Federal aid consists of 213.7 miles of graded and drained earth roads, 115.5 miles of sand-clay, 843.6 miles of gravel, 2.7 miles of water-bound macadam, 9.6 miles of bituminous macadam, and 433.9 miles of Portland cement concrete.

The total cost of the roads completed, including 27.1 miles of stage construction, was $2,688,018.38, of which the Federal share was $1,291,022.45. The disbursement of Federal funds to the State was $1,700,875.89. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $17,438,815, leaves a balance of $6,131,946.01 of unexpended funds to the credit of the State.

WYOMING

The Federal-aid highway system includes 3,071.7 miles, of which 1,225.1 miles have been improved with Federal aid. Of the improved mileage 187.3 miles were added during the year. At the close of the year 122.1 miles were under construction and 10.4 miles were approved.

The mileage improved with Federal aid consists of 359.8 miles of graded and

drained earth roads, 488.8 miles of sand-clay, 335.6 miles of gravel, 22.1 miles of bituminous concrete, and 14.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 4.1 miles.

The total cost of the roads completed, including 50.8 miles of stage construction, was $2,739,675.86, of which the Federal share was $1,725,258.41. The disbursement of Federal funds to the State was $1,212,767.42. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,566,274, leaves a balance of $1,330,970.09 of unexpended funds to the credit of the State.

Complete statistics of the Federal-aid roads completed during the year and during the entire period under the Federal-aid plan with reference to mileage and types completed and the total costs and Federal-aid allotments, etc., are given in Tables 9 to 19, inclusive.

TABLE 9.—*Total cost, Federal aid and mileage of Federal-aid roads, original and stage construction, completed during the fiscal year 1926, by States*

State	Total cost	Federal aid	Miles (original)	Miles (stage)
Alabama	$4,288,712.99	$1,831,731.14	262.0	
Arizona	1,378,605.07	885,678.50	96.5	
Arkansas	4,375,795.99	2,317,678.87	281.6	
California	5,727,131.79	2,752,692.79	222.8	7.1
Colorado	1,923,572.30	966,142.48	84.5	1.9
Connecticut	395,689.66	136,570.00	8.7	
Delaware	269,509.49	127,843.85	8.6	
Florida	1,700,890.98	818,937.01	36.9	
Georgia	5,141,532.68	2,504,419.51	322.7	20.4
Idaho	2,081,356.55	1,320,858.71	133.8	36.0
Illinois	5,177,738.18	2,532,879.71	182.4	.6
Indiana	5,432,841.65	2,584,668.72	157.2	
Iowa	2,589,254.14	1,170,140.16	138.6	12.4
Kansas	4,023,851.60	2,034,853.94	269.1	19.6
Kentucky	5,919,328.90	2,252,781.48	188.8	34.0
Louisiana	908,749.55	362,623.35	44.3	
Maine	388,599.74	192,580.02	15.6	
Maryland	1,985,590.44	901,945.32	103.3	
Massachusetts	3,717,850.99	932,863.07	56.8	
Michigan	4,599,169.26	1,985,509.96	134.1	3.9
Minnesota	7,435,078.06	3,173,974.52	528.0	174.9
Mississippi	4,340,617.88	2,169,238.93	286.4	36.6
Missouri	15,050,108.77	6,583,420.13	446.1	28.8
Montana	1,540,284.08	1,174,701.33	133.8	
Nebraska	1,412,172.43	682,658.91	146.5	209.4
Nevada	3,280,931.39	2,634,795.38	282.3	5.1
New Hampshire	884,824.61	424,791.20	29.6	
New Jersey	4,612,641.22	1,347,757.63	78.3	
New Mexico	1,483,178.56	908,377.49	137.5	15.8
New York	10,162,510.00	3,791,280.66	259.8	
North Carolina	7,385,531.70	3,056,122.87	164.6	61.0
North Dakota	1,780,585.28	907,695.08	260.4	318.2
Ohio	6,611,677.60	2,415,369.63	197.0	
Oklahoma	6,508,352.72	3,063,016.96	291.3	2.0
Oregon	2,616,671.11	1,434,973.97	132.4	7.7
Pennsylvania	23,774,022.81	6,574,796.61	447.6	
Rhode Island	1,165,514.70	390,685.01	23.5	
South Carolina	4,750,910.07	2,178,552.57	225.8	14.2
South Dakota	4,915,754.67	2,368,152.66	765.9	47.4
Tennessee	6,206,668.39	2,691,356.46	238.8	
Texas	9,403,940.27	4,348,097.85	723.5	41.3
Utah	1,705,348.27	1,185,427.86	135.2	
Vermont	1,239,157.62	565,771.50	27.2	
Virginia	5,097,604.77	2,302,948.28	190.5	
Washington	2,590,118.96	1,120,697.59	116.7	3.7
West Virginia	2,731,548.14	1,169,766.23	78.6	13.0
Wisconsin	2,688,018.38	1,291,022.45	134.5	27.1
Wyoming	2,739,675.86	1,725,258.41	187.3	50.8
Total	206,139,220.27	90,294,106.76	9,417.3	1,193.0

TABLE 10.—*Total cost, Federal aid and mileage of Federal-aid roads completed to June 30, 1926, by States*

State	Total cost	Federal aid	Miles [1]
Alabama	$20, 752, 585. 99	$9, 883, 424. 48	1, 415. 7
Arizona	11, 529, 325. 07	6, 250, 194. 69	767. 1
Arkansas	20, 257, 932. 75	8, 543, 898. 76	1, 418. 5
California	30, 235, 379. 81	14, 558, 628. 81	1, 169. 7
Colorado	15, 225, 844. 16	7, 801, 628. 50	797. 0
Connecticut	5, 977, 829. 01	2, 273, 863. 66	127. 1
Delaware	4, 918, 052. 29	1, 781, 665. 60	124. 3
Florida	7, 989, 517. 80	3, 878, 287. 87	249. 7
Georgia	27, 704, 198. 26	13, 109, 068. 58	1, 975. 5
Idaho	11, 780, 741. 23	6, 325, 103. 42	773. 7
Illinois	46, 638, 676. 52	21, 878, 422. 04	1, 467. 1
Indiana	22, 596, 658. 46	10, 900, 346. 83	687. 2
Iowa	30, 191, 682. 82	12, 432, 933. 15	2, 177. 0
Kansas	34, 446, 612. 82	13, 356, 124. 78	1, 263. 6
Kentucky	21, 319, 134. 37	8, 742, 516. 65	687. 4
Louisiana	14, 281, 859. 04	6, 359, 336. 43	1, 069. 8
Maine	8, 747, 552. 76	4, 192, 507. 39	303. 6
Maryland	10, 924, 943. 10	5, 112, 991. 22	423. 3
Massachusetts	19, 217, 639. 13	6, 898, 383. 20	385. 7
Michigan	27, 354, 859. 45	12, 474, 303. 21	995. 8
Minnesota	37, 850, 763. 95	15, 912, 616. 56	3, 249. 2
Mississippi	15, 716, 707. 96	7, 699, 843. 80	1, 158. 9
Missouri	37, 571, 342. 54	17, 289, 927. 52	1, 795. 7
Montana	11, 914, 279. 06	6, 607, 530. 55	1, 071. 5
Nebraska	14, 379, 018. 01	6, 868, 788. 86	2, 021. 2
Nevada	9, 315, 505. 61	6, 659, 890. 11	710. 1
New Hampshire	5, 260, 569. 51	2, 510, 351. 32	244. 6
New Jersey	17, 680, 844. 26	5, 378, 452. 37	307. 9
New Mexico	13, 200, 059. 12	7, 851, 157. 91	1, 490. 5
New York	45, 457, 079. 79	18, 626, 087. 19	1, 231. 8
North Carolina	30, 689, 430. 76	12, 741, 518. 72	1, 343. 1
North Dakota	13, 512, 576. 29	6, 602, 989. 10	2, 275. 7
Ohio	49, 367, 650. 24	18, 074, 453. 82	1, 422. 6
Oklahoma	28, 915, 946. 93	13, 484, 856. 58	1, 201. 5
Oregon	17, 612, 858. 41	8, 945, 203. 93	961. 6
Pennsylvania	74, 812, 072. 67	25, 106, 966. 83	1, 435. 2
Rhode Island	4, 320, 206. 69	1, 672, 904. 06	94. 3
South Carolina	17, 188, 668. 82	7, 779, 376. 11	1, 536. 9
South Dakota	18, 190, 591. 85	8, 948, 632. 65	2, 345. 8
Tennessee	23, 140, 785. 61	10, 995, 924. 33	835. 3
Texas	71, 403, 346. 64	28, 461, 138. 70	5, 055. 8
Utah	9, 054, 232. 80	5, 691, 043. 97	622. 6
Vermont	4, 273, 969. 26	2, 028, 484. 51	135. 2
Virginia	23, 410, 491. 32	10, 972, 568. 65	1, 050. 1
Washington	17, 078, 511. 63	7, 782, 909. 46	668. 6
West Virginia	10, 258, 141. 20	4, 491, 428. 66	414. 5
Wisconsin	25, 353, 034. 20	10, 638, 396. 73	1, 619. 1
Wyoming	12, 383, 388. 08	6, 977, 481. 63	1, 225. 1
Total	1, 051, 403, 098. 05	463, 554, 553. 90	55, 902. 8

[1] Mileage is of original improvement only.

TABLE 11.—*Total program, as of June 30, 1926, of projects which have been approved for construction, completed, and under construction*

State	Total cost	Federal aid	Miles [1]
Alabama	$23,284,832.30	$11,100,976.84	1,505.6
Arizona	12,434,048.56	6,859,370.61	823.4
Arkansas	23,512,523.69	10,108,969.67	1,662.9
California	39,081,457.75	18,833,239.76	1,396.1
Colorado	19,088,510.90	9,646,108.31	981.3
Connecticut	9,598,798.46	3,243,368.71	175.0
Delaware	6,657,124.45	2,476,554.40	168.2
Florida	13,757,718.54	6,470,127.88	412.6
Georgia	38,491,387.83	18,391,276.95	2,479.2
Idaho	14,786,598.24	8,125,589.22	959.7
Illinois	51,090,570.82	23,981,923.50	1,615.3
Indiana	34,437,733.91	16,373,269.82	1,014.0
Iowa	41,757,635.54	18,026,081.34	2,910.3
Kansas	46,397,579.03	17,883,140.14	1,942.4
Kentucky	26,464,612.40	11,206,226.75	1,041.9
Louisiana	18,142,124.68	8,195,790.12	1,247.0
Maine	12,456,663.60	5,603,302.50	416.5
Maryland	12,718,748.86	5,901,022.86	511.7
Massachusetts	23,291,788.14	7,991,338.63	442.2
Michigan	36,335,853.36	16,525,595.18	1,221.1
Minnesota	46,945,265.85	19,110,116.56	3,784.3
Mississippi	23,692,089.82	11,565,407.79	1,584.7
Missouri	50,773,350.17	22,380,474.90	2,129.9
Montana	14,921,271.47	8,873,740.57	1,333.3
Nebraska	25,825,944.03	12,454,863.87	3,214.4
Nevada	11,063,376.38	8,151,533.26	927.7
New Hampshire	6,091,694.33	2,878,433.12	270.5
New Jersey	23,727,643.27	7,767,919.65	331.9
New Mexico	14,321,053.77	8,670,686.83	1,561.4
New York	85,507,902.79	29,081,137.39	1,901.0
North Carolina	35,680,608.02	14,979,929.82	1,474.2
North Dakota	20,676,546.93	10,244,297.92	3,315.2
Ohio	62,234,909.87	22,993,480.84	1,803.4
Oklahoma	31,867,684.07	14,858,244.75	1,341.0
Oregon	20,700,118.70	10,624,852.11	1,087.5
Pennsylvania	89,685,731.95	29,639,774.39	1,775.9
Rhode Island	6,005,811.05	2,110,349.06	123.5
South Carolina	21,714,922.77	9,764,377.98	1,742.0
South Dakota	21,736,291.75	10,767,488.42	2,934.3
Tennessee	30,769,343.75	14,395,266.07	1,053.0
Texas	90,672,097.66	36,969,487.39	5,889.0
Utah	10,728,064.59	6,967,500.25	749.8
Vermont	6,151,017.44	2,762,711.14	170.6
Virginia	28,860,277.96	13,399,057.56	1,202.1
Washington	21,559,979.03	9,850,509.46	755.0
West Virginia	15,961,339.69	6,721,219.19	570.3
Wisconsin	33,434,428.85	14,587,911.92	2,008.3
Wyoming	13,690,412.82	7,785,318.07	1,357.6
Hawaii	1,050,897.93	312,635.18	15.9
Total	1,369,836,387.77	597,605,998.65	69,334.1

[1] Mileage is of original improvement only.

TABLE 12.—*Mileage of Federal-aid roads completed during the fiscal year 1926, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land cement con-crete	Brick	Bridges	Total
Alabama	25.1	101.6	117.5	.....	[1] −20.2	[1] −5.9	43.3	.....	0.6	262.0
Arizona	[1] −47.4	66.4	62.3	.....	.....	6.2	9.2	.....	.....	96.6
Arkansas	.....	.....	191.9	7.9	23.0	5.0	53.7	.....	.3	281.6
California	31.5	.....	70.6	.....	.....	17.7	102.2	.....	.8	222.8
Colorado	3.4	1.0	61.0	.....	.....	.....	18.4	.....	.7	84.5
Connecticut	.....	.....	.....	.....	.....	.....	8.7	.....	.....	8.7
Delaware	.....	.....	.....	.....	.....	.....	8.6	.....	.....	8.6
Florida	[1] −8.2	.....	.....	13.6	7.8	10.5	11.0	.....	2.3	36.9
Georgia	31.1	169.8	62.3	8.8	19.8	3.4	23.7	.....	4.1	322.7
Idaho	12.9	[1] −.2	109.1	.....	.....	.7	11.5	.....	.....	133.8
Illinois	.....	.....	.....	.....	.....	.....	182.1	.....	.....	182.4
Indiana	5.8	.....	6.4	[1] −7.5	.....	.....	152.6	.....	.....	157.2
Iowa	64.2	.....	36.1	.....	.....	.....	38.5	.....	.1	138.6
Kansas	148.1	17.0	58.7	.....	28.1	.4	[1] −1.7	17.4	.8	269.1
Kentucky	101.2	.....	8.2	.3	34.0	.....	45.9	.....	[1] −.6	188.8
Louisiana	.....	.....	36.9	.....	.....	2.8	3.6	.....	1.2	44.3
Maine	.....	.....	6.2	.....	9.4	.....	.....	.....	.....	15.6
Maryland	.9	.....	.....	.....	65.3	.....	37.3	.....	.....	103.3
Massachusetts	.....	.....	.....	.....	14.8	6.6	34.2	.....	1.2	56.8
Michigan	3.5	.....	[1] −.5	.....	5.4	[1] −2.7	128.4	.....	.....	134.1
Minnesota	144.4	6.2	351.4	.....	.....	2.0	23.8	.....	.2	528.0
Mississippi	12.8	2.2	247.2	.....	.....	.....	23.7	.....	.3	286.4
Missouri	63.5	.....	117.6	.....	1.9	.....	256.4	2.3	4.4	446.1
Montana	[1] −1.6	5.6	127.8	.....	.....	1.9	.....	.....	.4	133.8
Nebraska	[1] −.3	37.0	113.6	.....	.....	.7	[1] −7.3	.....	2.3	146.5
Nevada	19.1	1.5	251.1	10.2	[1] −5.0	.4	4.4	.....	.7	282.3
New Hampshire	.....	.....	1.7	14.5	11.1	.....	.9	.....	1.3	29.6
New Jersey	.....	.8	.5	.....	.....	9.3	67.2	.....	.6	78.3
New Mexico	33.5	.....	93.1	.....	.....	.....	10.5	.....	.5	137.5
New York	.....	.....	8.6	.....	52.8	.....	198.5	.....	.....	259.8
North Carolina	12.1	.....	.....	.....	.....	63.3	88.9	.....	.3	164.6
North Dakota	228.8	.....	31.2	.....	.....	.....	.....	.....	.6	260.4
Ohio	15.8	.....	.....	.....	56.8	.....	76.2	48.0	.....	197.0
Oklahoma	75.9	.....	69.0	.....	7.8	.....	132.2	4.9	1.5	291.3
Oregon	42.2	.....	82.6	.....	.8	.....	5.8	.....	1.2	132.4
Pennsylvania	32.9	.....	.....	.....	.....	[1] −.8	414.2	1.2	.....	447.6
Rhode Island	.....	.....	.....	1.9	6.0	1.3	14.2	.....	.....	23.5
South Carolina	26.2	155.4	13.6	6.0	.....	10.4	10.2	.....	4.0	225.8
South Dakota	323.9	.....	440.7	.....	.....	.....	.4	.....	.8	765.9
Tennessee	127.5	.....	22.6	.....	38.4	.....	49.5	.....	.8	238.8
Texas	375.3	29.3	161.1	2.5	107.1	44.0	14.2	4.4	[1] −14.9	723.5
Utah	[1] −6.9	4.1	131.4	.....	.7	2.1	3.6	.....	.3	135.2
Vermont	.....	.....	14.3	.....	5.3	.....	5.3	.....	2.4	27.2
Virginia	24.7	2.4	29.2	.....	62.9	.....	71.1	.....	.3	190.5
Washington	65.2	.....	19.9	.....	.....	.....	31.3	.....	.3	116.7
West Virginia	40.0	3.9	.....	.....	19.1	.....	15.3	.....	.3	78.6
Wisconsin	9.4	.....	82.0	.....	.....	.....	43.0	.....	.....	134.5
Wyoming	125.0	23.5	37.7	.....	.....	.....	.....	.....	1.1	187.3
Total	2,161.3	627.3	3,274.1	58.2	553.2	179.6	2,464.3	78.1	21.3	9,417.3

[1] Negative figures caused by revision of records when final vouchers were paid on projects the type of which was changed after ratification of project agreement.

TABLE 13.—*Mileage of Federal-aid roads completed to June 30, 1926, by types of construction*

States	Graded and drained	Sand-clay	Gravel	Water-bound macad-am	Bitu-minous macad-am	Bitu-minous con-crete	Port-land cement concrete	Brick	Bridges	Total
Alabama	28.3	417.5	768.6	6.0	58.8	80.8	52.9		2.8	1,415.7
Arizona	92.4	122.3	404.8	14.2		22.7	108.6		2.2	767.1
Arkansas		3.1	919.2	48.2	84.1	248.4	114.1		1.6	1,418.5
California	276.9		280.4	18.1	55.5	67.3	468.9		2.6	1,169.7
Colorado	172.5	76.8	352.7			5.9	184.7		4.4	797.0
Connecticut				8.8	27.0		91.3			127.1
Delaware							117.9	6.2	.2	124.3
Florida	11.8	34.1		13.6	72.6	23.3	81.7	10.1	2.6	249.7
Georgia	96.2	1,194.9	345.7	41.7	95.9	15.9	161.9	.5	23.1	1,975.5
Idaho	165.6	18.6	514.0	4.3		37.6	32.8		1.1	773.7
Illinois	112.3				3.3	8.1	1,315.9	25.8	1.4	1,467.1
Indiana	25.6		33.5		17.0	12.0	597.6		1.6	687.2
Iowa	1,303.4		425.5				425.9	22.0	.3	2,177.0
Kansas	313.0	112.2	180.8	4.5	84.6	3.5	439.2	123.0	2.5	1,263.6
Kentucky	388.9		118.9	41.4	139.8		94.5	3.9	.2	787.4
Louisiana	3.4		1,037.1	3.2	9.5	10.4	3.6		2.8	1,069.8
Maine			126.7		137.4		39.3		.2	303.6
Maryland	4.7		31.5	.1	106.9	12.3	268.0			423.3
Massachusetts				3.3	199.2	36.8	143.9		2.5	385.7
Michigan	29.2		316.1	18.9	10.4	73.4	547.4	.4		995.8
Minnesota	379.0	6.2	2,500.0			27.9	335.5		.6	3,249.2
Mississippi	136.4	20.6	873.6	11.1	1.0	9.2	97.1	9.2	.5	1,158.9
Missouri	326.8		842.9	13.4	50.8	17.7	528.2	8.5	7.4	1,795.7
Montana	214.2	5.6	792.7	16.0	6.9	2.8	31.3		2.3	1,071.5
Nebraska	1,213.9	169.2	559.2			10.1	46.5	18.6	3.2	2,021.2
Nevada	53.8	26.4	555.3	10.2	15.6	2.0	44.8		2.1	710.1
New Hampshire			96.5	46.5	63.9	30.0	5.2		2.4	244.6
New Jersey	1.6	.8	3.9			21.9	279.1		.7	307.9
New Mexico	225.8	5.1	1,181.2			.7	76.5		1.3	1,490.5
New York			8.6		320.7	4.8	895.6	.7	1.5	1,231.8
North Carolina	80.7	520.6	85.8	19.6	38.0	228.6	367.9		1.9	1,343.1
North Dakota	1,348.4	1.5	919.6			1.2	3.0		2.2	2,275.7
Ohio	47.0			82.6	303.1	88.1	454.5	447.0	.1	1,422.6
Oklahoma	114.3	2.3	595.7	6.3	8.4	64.5	391.7	8.9	9.4	1,201.5
Oregon	132.6		656.1	25.6	.8	52.9	91.5		2.3	961.6
Pennsylvania	32.9				7.8	101.1	1,266.9	26.4		1,435.2
Rhode Island				1.9	16.5	38.3	37.5			94.3
South Carolina	34.2	1,232.7	114.5	6.0	3.0	63.5	75.0	.2	7.8	1,536.9
South Dakota	481.1	18.2	1,843.3				1.2		1.9	2,345.8
Tennessee	140.6		117.0	52.3	401.8	21.9	100.3		1.4	835.3
Texas	672.7	83.9	2,862.6	476.9	449.7	121.7	351.7	29.2	6.9	5,055.8
Utah	94.2	41.7	373.7	9.3	.7	9.9	91.6		1.6	622.6
Vermont			87.1	3.4	25.0		16.1		3.7	135.2
Virginia	51.7	202.1	113.9	103.5	249.1	10.6	312.7		1.6	1,050.1
Washington	108.8		311.3				246.4		2.1	668.6
West Virginia	165.4	5.6	18.3	4.9	101.9	16.3	90.2	11.4	.5	414.5
Wisconsin	213.7	115.5	843.6	2.7	9.6		433.9			1,619.1
Wyoming	359.8	488.8	335.6			22.1	14.7		4.1	1,225.1
Total	9,653.7	4,926.2	22,547.3	1,123.3	3,176.3	1,626.1	11,976.6	752.0	121.6	55,902.8

TABLE 14.—*Mileage of Federal-aid roads under construction on June 30, 1926, by types of construction*

States	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	44.1				9.3	6.8	28.9		0.9	89.9
Arizona		16.2	27.7						.3	44.1
Arkansas			156.8	12.1	42.5		.6		1.2	213.3
California	57.8		74.7			9.2	64.2		2.3	208.2
Colorado	80.9	6.9	55.2				18.1		1.4	162.5
Connecticut	1.5			2.2			33.6		.7	38.0
Delaware							28.2		.1	28.2
Florida	65.9		8.2	22.9	7.1	32.4	22.3		4.1	162.9
Georgia	127.0	179.1	75.0	35.6	14.3	7.5	34.5		2.4	475.4
Idaho	8.1	6.0	79.1			8.6	11.4		.4	113.5
Illinois	1.6						122.7			124.4
Indiana	3.1			45.1			214.2	11.0	1.8	275.1
Iowa	368.8		69.3				148.2		.4	586.7
Kansas	345.3	38.9	29.6		39.9		66.5	25.1	3.6	548.9
Kentucky	231.1				12.0		7.7		.1	250.9
Louisiana	21.8		124.6						.9	147.4
Maine			35.1		15.0		16.2		1.1	67.3
Maryland					4.9		25.8			30.7
Massachusetts					13.3		20.2		1.8	35.4
Michigan	10.1		40.4				162.9		.3	213.7
Minnesota	279.4		137.7			4.8	102.0			524.0
Mississippi	134.8		138.3				57.5		.1	330.7
Missouri	51.3		21.2				223.0	12.5	3.0	311.1
Montana			116.1							116.1
Nebraska	319.8	90.3	667.0				20.3		1.9	1,099.2
Nevada	5.4		164.2		4.7				.5	174.8
New Hampshire			1.6	9.1	6.9		1.3		.1	19.0
New Jersey	4.5						8.7		.8	14.0
New Mexico			34.1				2.4		.3	36.9
New York	35.2		38.2		37.6	7.0	414.5			532.6
North Carolina						8.6	95.8		.6	105.0
North Dakota	494.6	11.1	143.7				.4		.8	650.7
Ohio	37.5			28.3	86.0	5.7	119.6	17.4	.5	295.0
Oklahoma	33.2		15.3			5.7	18.3		2.3	74.8
Oregon	56.1		47.5						.4	103.9
Pennsylvania	97.7						185.5			283.3
Rhode Island					6.6	2.4	11.9			20.9
South Carolina	20.6	*124.4	18.5			4.4	13.8		4.3	185.9
South Dakota	385.1		83.2						.4	468.7
Tennessee	93.3		6.8		28.3	5.8	58.3		.5	193.1
Texas	179.5		165.6	44.9	211.5	28.0	141.5		.8	771.8
Utah			77.6						.1	77.8
Vermont			12.7		9.9		9.2		2.1	33.9
Virginia	3.2	12.0	6.1		60.3		58.4		1.1	141.1
Washington	17.0		22.0						2.0	41.1
West Virginia	16.4				32.9	24.5	41.7			115.5
Wisconsin			187.9		4.2		92.5		1.9	286.4
Wyoming	53.8		64.2				4.1		.1	122.1
Hawaii						6.5	9.4			15.9
Total	3,685.6	484.9	2,945.2	200.2	647.2	167.9	2,716.4	66.0	48.4	10,961.8

TABLE 15.—*Mileage of Federal-aid roads approved for construction on June 30, 1926*

States	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Arizona	12.2									12.2
Arkansas			29.5				1.7			31.1
California							18.2			18.2
Colorado			10.1				11.6		0.1	21.8
Connecticut							9.6		.3	9.9
Delaware							15.5		.3	15.7
Georgia	11.8	12.0	4.4	0.2						28.3
Idaho	55.2		8.6				7.7		.9	72.5
Illinois							24.0			24.0
Indiana							51.3		.4	51.7
Iowa	109.7		29.4				7.1		.6	146.8
Kansas	99.7	4.2	10.0		3.1		11.9		1.1	129.9
Kentucky	3.6									3.6
Louisiana			22.6				7.1		.1	29.8
Maine			29.9		4.8		10.8		.1	45.6
Maryland					11.7		46.0			57.7
Massachusetts					12.5		8.6			21.1
Michigan			8.5				3.1			11.6
Minnesota	11.1									11.1
Mississippi	48.3		40.6				5.7	0.5		95.1
Missouri	4.5						18.7			23.1
Montana	25.2		120.4						.1	145.7
Nebraska	53.0	1.8	37.8				.4		1.0	94.0
Nevada			42.8							42.8
New Hampshire			1.5	.5	3.3		1.0		.6	6.9
New Jersey							10.0			10.0
New Mexico	11.5		22.5							34.0
New York			4.6				132.1			136.6
North Carolina							26.1			26.1
North Dakota	356.5	9.4	21.7				.7		.4	388.8
Ohio	7.6			11.8	5.5		59.8	1.0		85.8
Oklahoma	57.4						7.1		.1	64.7
Oregon			13.2				8.8			22.0
Pennsylvania	9.6						47.8			57.4
Rhode Island					4.4	0.9	3.0			8.3
South Carolina		17.1							2.2	19.2
South Dakota	119.8								.1	119.8
Tennessee	12.7					6.3	5.6			24.6
Texas	39.3		11.8		6.4		2.5		1.4	61.4
Utah			49.4							49.4
Vermont							1.5			1.5
Virginia	3.9		.2		4.2		2.7			10.9
Washington	8.1		10.5				26.7			45.3
West Virginia	22.9						16.8		.6	40.3
Wisconsin	9.0		72.7				20.9		.2	102.8
Wyoming	6.2		4.2							10.4
Total	1,098.8	44.4	606.9	12.5	55.9	7.1	632.1	1.5	10.7	2,469.5

TABLE 16.—*Mileage of stage construction completed during fiscal year 1926, by types of construction*

State	Sand-clay	Gravel	Water-bound macadam	Bitu-minous macadam	Bitu-minous concrete	Portland cement concrete	Total
California						7.1	7.1
Colorado					1.9		1.9
Georgia		4.2			0.9	15.3	20.4
Idaho		34.2			1.8		36.0
Illinois						0.6	.6
Iowa						12.4	12.4
Kansas	7.0				3.1	9.5	19.6
Kentucky		28.5				5.5	34.0
Michigan						3.9	3.9
Minnesota		135.2				39.7	174.9
Mississippi	.8	35.8					36.6
Missouri		9.3				19.5	28.8
Nebraska		197.9				11.5	209.4
Nevada		5.1					5.1
New Mexico		15.0				.8	15.8
North Carolina			6.8		23.8	30.4	61.0
North Dakota		318.2					318.2
Oklahoma						2.0	2.0
Oregon		7.7					7.7
South Carolina						14.2	14.2
South Dakota		47.4					47.4
Texas				33.3		8.0	41.3
Washington						3.7	3.7
West Virginia				13.0			13.0
Wisconsin		15.5				11.6	27.1
Wyoming		32.8			18.0		50.8
Total	7.8	886.7	6.8	46.3	49.5	195.7	1,193.0

TABLE 17.—*Mileage of projects on which stage construction was in progress on June 30, 1926*

State	Gravel	Water-bound macadam	Bitu-minous macadam	Bitu-minous concrete	Portland cement concrete	Brick	Total
Alabama					4.8		4.8
Colorado				6.7			6.7
Georgia		18.8	10.1		31.9		60.8
Idaho				15.5	.2		15.7
Illinois					2.0		2.0
Indiana		11.6					11.6
Iowa	38.9				2.3		41.2
Kentucky	25.5				14.6		40.1
Michigan					25.6		25.6
Minnesota	49.0				49.2		98.2
Missouri	8.2				14.7		22.9
Montana	41.6	4.1					45.7
Nebraska	571.3						571.3
Nevada			15.6				15.6
North Carolina					14.8		14.8
North Dakota	157.3						157.3
Ohio		6.7			5.9	0.8	13.4
Oklahoma					17.4		17.4
South Carolina				14.7			14.7
South Dakota	44.0						44.0
Tennessee					28.0		28.0
Texas		34.1	10.8		16.4		61.3
West Virginia				8.0			8.0
Wisconsin	7.8						7.8
Total	943.6	75.3	36.5	44.9	227.8	0.8	1,328.9

TABLE 18.—*Status of Federal highway system June 30, 1926*

State	Mileage of Federal-aid system approved to June 30, 1926	Federal-aid mileage completed during fiscal year	Federal-aid mileage completed to June 30, 1926
Alabama	3,872.0	262.0	1,415.7
Arizona	1,498.0	96.6	767.1
Arkansas	5,007.0	281.6	1,418.5
California	4,574.4	222.8	1,169.7
Colorado	3,332.0	84.5	797.0
Connecticut	835.4	8.7	127.1
Delaware	385.2	8.6	124.3
Florida	1,926.0	36.9	249.7
Georgia	5,558.4	322.7	1,975.5
Idaho	2,768.6	133.8	773.7
Illinois	5,002.2	182.4	1,467.1
Indiana	4,679.0	157.2	687.2
Iowa	7,212.0	138.6	2,177.0
Kansas	7,892.0	269.1	1,263.6
Kentucky	3,701.0	188.8	787.4
Louisiana	2,664.0	44.3	1,069.8
Maine	1,393.5	15.6	303.6
Maryland	1,479.2	103.3	423.3
Massachusetts	1,308.0	56.8	385.7
Michigan	5,235.0	134.1	995.8
Minnesota	6,849.6	528.0	3,249.2
Mississippi	3,604.0	286.4	1,158.9
Missouri	7,530.0	446.1	1,795.7
Montana	4,661.0	133.8	1,071.5
Nebraska	5,569.1	146.5	2,021.2
Nevada	1,398.0	282.3	710.1
New Hampshire	977.4	29.6	244.6
New Jersey	1,198.3	78.3	307.9
New Mexico	3,298.0	137.5	1,490.5
New York	5,018.0	259.8	1,231.8
North Carolina	3,781.0	164.6	1,343.1
North Dakota	6,836.0	260.4	2,275.7
Ohio	5,900.5	197.0	1,422.6
Oklahoma	5,528.0	291.3	1,201.5
Oregon	2,814.0	132.4	961.6
Pennsylvania	4,090.5	447.6	1,435.2
Rhode Island	242.4	23.5	94.3
South Carolina	3,230.0	225.8	1,536.9
South Dakota	5,731.0	765.9	2,345.8
Tennessee	3,252.8	238.8	835.3
Texas	11,129.0	723.5	5,055.8
Utah	1,588.0	135.2	622.6
Vermont	1,043.0	27.2	135.2
Virginia	3,075.5	190.5	1,050.1
Washington	2,907.7	116.7	668.6
West Virginia	1,994.0	78.6	414.5
Wisconsin	5,493.4	134.5	1,619.1
Wyoming	3,071.7	187.3	1,225.1
Total	182,134.8	9,417.3	55,902.8

TABLE 19.—*Federal-aid apportionments to States, expenditures, and balances, as of June 30, 1926*

State	Apportionments	Expenditures	Balances unexpended
Alabama	$14,349,455.00	$9,919,182.48	$4,430,272.52
Arizona	9,617,249.00	6,259,140.19	3,358,108.81
Arkansas	11,605,804.00	9,102,538.31	2,503,265.69
California	22,072,815.00	16,120,155.30	5,952,659.70
Colorado	12,325,812.00	8,129,488.18	4,196,323.82
Connecticut	4,333,681.00	2,352,862.75	1,980,818.25
Delaware	2,474,058.00	1,917,078.26	556,979.74
Florida	8,084,954.00	4,849,004.58	3,235,949.42
Georgia	18,431,953.00	15,440,114.91	2,991,838.09
Idaho	8,559,627.00	6,689,044.87	1,870,582.13
Illinois	29,832,198.00	22,546,816.03	7,285,381.97
Indiana	18,204,355.00	13,505,029.08	4,699,325.92
Iowa	19,485,563.00	13,801,842.35	5,683,720.65
Kansas	19,464,411.00	14,672,787.93	4,791,623.07
Kentucky	13,212,809.00	9,910,161.61	3,302,647.39
Louisiana	9,272,408.00	7,033,966.34	2,238,441.66
Maine	6,464,828.00	4,506,120.68	1,958,707.32
Maryland	5,925,057.00	5,146,096.97	778,960.03
Massachusetts	10,108,726.00	6,794,128.62	3,314,597.38
Michigan	20,342,365.00	14,663,354.69	5,679,010.31
Minnesota	19,591,780.00	16,932,876.54	2,658,903.46
Mississippi	12,128,018.00	9,120,178.69	3,007,839.31
Missouri	22,786,436.00	16,797,074.09	5,989,361.91
Montana	13,424,885.00	6,882,815.49	6,542,069.51
Nebraska	14,635,235.00	8,863,931.59	5,771,303.41
Nevada	8,795,215.00	7,493,361.19	1,301,853.81
New Hampshire	3,169,492.00	2,481,613.23	687,878.77
New Jersey	8,467,420.00	6,762,771.79	1,704,648.21
New Mexico	10,972,386.00	7,874,860.93	3,097,525.07
New York	34,045,195.00	20,677,305.80	13,367,889.20
North Carolina	15,717,206.00	12,874,689.22	2,842,516.78
North Dakota	10,748,659.00	6,800,708.71	3,947,950.29
Ohio	25,731,796.00	19,172,556.90	6,559,239.10
Oklahoma	16,059,787.00	13,660,412.30	2,399,374.70
Oregon	10,879,347.00	9,448,016.39	1,431,330.61
Pennsylvania	31,338,781.00	25,427,918.97	5,910,862.03
Rhode Island	2,667,569.00	1,558,829.06	1,108,739.94
South Carolina	9,801,524.00	8,247,733.92	1,553,790.08
South Dakota	11,166,790.00	9,370,161.58	1,796,628.42
Tennessee	15,280,591.00	12,077,084.81	3,203,506.19
Texas	40,606,431.00	31,411,089.08	9,195,341.92
Utah	7,818,779.00	6,028,762.02	1,790,016.98
Vermont	3,268,507.00	2,161,390.47	1,107,116.53
Virginia	13,501,514.00	11,401,105.73	2,100,408.27
Washington	10,145,776.00	8,337,999.77	1,807,776.23
West Virginia	7,352,511.00	5,465,643.81	1,886,867.19
Wisconsin	17,438,815.00	11,306,868.99	6,131,946.01
Wyoming	8,566,274.00	7,235,303.91	1,330,970.09
Hawaii	1,100,153.00	68,556.62	1,031,596.38
Total	671,375,000.00	499,300,535.73	172,074,464.27

NATIONAL FOREST ROAD CONSTRUCTION

The appropriations for forest road construction are being expended in the several States in which the forests are located on specifically designated systems of forest highways comprising a total of 13,459 miles, of which 11,271 miles are in the 11 States of the Mountain and Pacific groups and the Territory of Alaska.

In all States affected, with the exception of New Mexico and Oregon, the designation of these systems is the result of agreement between the State highway departments, the Forest Service, and the Bureau of Public Roads, and has been formally approved by the Secretary of Agriculture. In the two States mentioned as exceptions final agreement between the cooperating agencies has not yet been reached and the systems have not been approved by the Secretary, but pending final action work is proceeding upon systems designated by the Bureau of Public Roads.

The highways comprising the systems in the several States are classified according to their character as class 1 highways, which are necessary sections or extensions of the Federal-aid system lying wholly within the forests; class 2 highways which are extensions of the Federal-aid systems extending to towns outside of the forests, and class 3 highways which are largely of local service to communities within the forests.

The mileage of the systems in the several States, classified as above described, is given in Table 20.

TABLE 20.—*Classified mileage of forest highway systems in the several States*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Western:	*Miles*	*Miles*	*Miles*	*Miles*
Alaska			316.5	316.5
Arizona	174	473	246	893
California	312.9	995.6	737	2,045.5
Colorado		1,243	527	1,770
Idaho		754	347	1,101
Montana	145	652	377	1,174
Nevada		366	94	460
New Mexico [1]	115	211	199	525
Oregon [1]	58	872.4	445	1,375.4
Utah		415	237	652
Washington	18.4	263.7	147.8	429.9
Wyoming		380	149	529
Total	823.3	6,625.7	3,822.3	11,271.3
Eastern:				
Alabama			34	34
Arkansas	131	51	20	202
Florida	3	13	106	122
Georgia			81	81
Maine			11	11
Michigan			20	20
Minnesota		38.5	142	180.5
Nebraska			25	25
New Hampshire	18.3	15.5	61	94.8
North Carolina	49		196	245
Oklahoma			33	33
Pennsylvania	24.5		166	190.5
South Carolina		6	22	28
South Dakota	2	153	59	214
Tennessee		55	188	243
Virginia		28	273	301
West Virginia		4	159	163
Total	227.8	364	1,596	2,187.8
Grand total	1,051.1	6,989.7	5,418.3	13,459.1

[1] System designated by the Bureau of Public Roads not yet approved by Secretary of Agriculture.

It is planned to expend approximately 70 per cent of each annual appropriation for the construction of the highways of classes 1 and 2, which undoubtedly serve the greatest traffic at present, using the balance for the improvement of the class 3, or local forest highways. The administration, survey, and construction of these highways and their maintenance for the first two years, constituting the principal road construction activity conducted independently by the United States Government, has been delegated to the Bureau of Public Roads.

There were 622.5 miles of forest highway projects completed, which, added to the mileage completed previously, bring the total of improved mileage up to 3,045.6 miles, equivalent to 22.6 per cent of the designated systems. The mileage completed in the several States during the year and to date is shown in Table 21.

TABLE 21.—*Mileage of completed forest highway projects by states.*

State	Mileage of forest highway projects completed	
	During 1926	Total to June 30, 1926
Western:	*Miles*	*Miles*
Alaska	30.7	146.4
Arizona	89.2	216.6
California	56.4	202.6
Colorado	32.1	211.4
Idaho	44.4	383.6
Montana	66.9	303.3
Nevada	9.4	94.2
New Mexico	44.3	164.1
Oregon	133.5	464.9
Utah	16.3	259.0
Washington	29.6	184.1
Wyoming	39.6	173.8
Total	592.4	2,804.0
Eastern:		
Arkansas	2.3	56.8
Florida	6.2	64.2
Georgia		8.6
Minnesota	19.4	34.6
New Hampshire	2.2	2.2
North Carolina		16.4
South Carolina		5.3
South Dakota		34.8
Tennessee		12.2
Virginia		6.5
Total	30.1	241.6
Grand total	622.5	3,045.6

Outstanding among the forest highways recently completed are such noteworthy projects as the Mount Hood Loop road in Oregon, the Prescott-White Spar road in Arizona, the Warm River-Yellowstone road in Idaho, the Smith River Canyon road in northern California, the Neskowin-Siletz River road in Oregon, the Berthoud Pass road in Colorado, the Canoncito-Pecos road in New Mexico, and the Cody-Yellowstone road in Wyoming. For the engineering features involved in their construction and the difficulties overcome these roads are not surpassed in the world.

FEDERAL-AID AND FOREST ROAD WORK ASSOCIATED IN WEST

In 1916, when the Federal-aid policy was inaugurated, the States of the mountain and Pacific groups were just beginning systematic highway construction. California had been operating for five years, Washington had made considerable progress, and Colorado and a few of the other States had begun work. The Federal legislation immediately stabilized State highway operations in all of these States and

strengthening legislation has since followed.

The terrain of this western region is characterized by high mountains and broad desert areas. Through and across these mountains and deserts highway construction is expensive and difficult but absolutely necessary to serve the fertile valleys and irrigated semiarid sections in which many people live, as well as to facilitate through transportation between the Mississippi Valley and the west coast.

Of this great western area the national forests occupy approximately 17 per cent, the national parks a fraction of 1 per cent, and the rest of the public domain, including Indian reservations, nearly 30 per cent. These vast nationally-owned and sparsely inhabited areas are so located that they separate the fertile and inhabited sections and must, therefore, be crossed in passing from one community to another. Yet the States in which they lie have no jurisdiction over them, nor power to tax the land for purposes of highway construction; consequently connected highway development would be an impossibility without the cooperation of the Federal Government.

Recognizing this condition, Congress has made appropriations each year since 1917 for the purpose of building roads in and across the forest areas and to towns adjacent thereto. In 1921 it adopted the so-called sliding scale of Federal-aid participation which permits an increase of the normal 50 per cent participation by an amount proportionate in each State to the percentage of unappropriated public land, exclusive of the national forests and parks. The law also permits the Secretary of Agriculture to pay the entire cost of projects in Indian reservations. Thus, by making independent provision for the construction of roads in the forest, park, and Indian reservations, and by increasing the allowable percentage of participation in Federal-aid projects in other parts of these States, the United States has sought to bear its proper share of the cost of supplying the necessary improved highway facilities, not only for its own domain, but, by suitable connection with the State highways, for the entire region.

It follows, therefore, that the forest road construction and the national parks road work for which the United States has made itself solely responsible should be carried on in harmonious relation to the cooperative Federal-aid construction and the unaided construction of the State highway departments. This, happily, is being accomplished under the present arrangements, whereby the forest road program is determined upon by agreement between the State officials and officers of the two Federal bureaus, and the National Park Service of the Interior Department is cooperating closely with the Department of Agriculture.

Thanks to the sliding-scale provisions of the Federal highway act, highways have been rapidly extended across desolate and almost impassable areas, particularly in the arid Southwest, and the forest road appropriations have permitted the improvement of vital connecting links on transcontinental routes.

Necessarily the forest highway appropriations have taken the heaviest burden because the forests lie in the mountains where topography is rugged, the working season short, and the location remote, all factors which spell high unit costs of construction. Yet, despite these handicaps, prices of 65 and 75 cents a cubic yard for unclassified excavation have not been uncommon.

The improvement of these highways, both the Federal-aid and forest sections, has of necessity been limited in the beginning to first-stage construction, but it has enabled the traffic to pass with increasing safety, speed, and comfort, and the remaining unimproved gaps are being rapidly closed. Meanwhile, as the traffic increases standards of construction are being constantly raised. Grades and curvature are being reduced and widths increased, and projects constructed originally as unsurfaced earth roads are being surfaced.

HIGHWAY RESEARCH

The physical and economic researches which have been carried on by the bureau for several years have for their purpose the establishment of scientific facts as a means of promoting economy in the expenditure of highway funds. This work, which is regarded as a most important function of the bureau, results each year in the development of information of immediate practical significance and in the accumulation of a mass of detailed observational data which, as its volume grows, is perhaps of even greater value than the immediate benefits.

Among the investigations which have produced results of direct practical application, one of the most important is that which has had for its object the promotion of the efficiency of various operations of road construction. This is a continuation of work which was well advanced during the preceding year.

So far the studies have been confined to operations of earth moving and concrete-pavement construction in which there is perhaps the greatest opportunity for substantial saving.

The method employed in both cases has been the same. The object has been to ascertain and measure the preventable losses of time in construction operations, and this has been accomplished by timing such operations with a stop watch on actual construction projects with histories of progress indicating various degrees of efficiency. The comparatively low average efficiency of current work revealed is not alarming. It is not lower than that which prevails in most construction and manufacturing operations; but the simplicity of the methods which have been developed for the elimination of the various losses is distinctly encouraging and the results that have been obtained when these methods have been applied both by engineers of the bureau and by contractors is very gratifying indeed.

Savings of from 25 to 35 per cent are shown to be generally possible by the earth-moving studies. This result is attained by the selection of the kind of grading equipment best suited to the prevailing length of haul on the project, whether slip scrapers, fresnoes, wheel scrapers, elevating graders, steam shovels, or other type, and by the proper adjustment of the number of units of equipment as the length of hauls varies within the general limits for the job as the work progresses.

The most far-reaching of the indications of these studies is that which points to the desirability of a departure from the practice long employed in the design of railroad and highway grades, of balancing cuts and fills in favor of a design which will render more nearly of uniform length the haul of material from cut to embankment in all parts of the project, and which will reduce the length of haul to a minimum. With a given limiting gradient and rate of curvature and practically without change in the quantity of earth moved it has been found possible to reduce by as much as 20 per cent the cost of grading with an elevating-grader outfit by this method of design in comparison with the older method. This is the saving possible from the change in design alone and does not include the savings which ordinarily may be made on any job by improvements in managerial efficiency.

INCREASED OUTPUT IN PAVING

The studies of concrete-paving operations indicate that there are few projects on which the average daily output can not be increased 25 per cent, and many on which it is possible to obtain increases of 50 and even 100 per cent. The preventable losses in work of this character are mainly the result of maladjustment of material-hauling equipment in number and character to the capacity of the concrete mixer.

By careful elimination of such losses engineers of the bureau have made astonishing increases in the output of working organizations, but more gratifying than these results has been the success which has attended the efforts of contractors, who have made an effort to apply similar methods. In one case of which we have received a report the contractor was able, by his own efforts, to increase the production of pavement from 350 to 600 feet daily; and in another case in the same State the daily footage was increased from 600 to 1,000. Still more gratifying is the fact that on the next contracts obtained by these two contractors, involving 40 miles of concrete pavement, the price bid was $37,000 less than the normal. Another indication of the effectiveness of the methods is furnished by the fact that on eight jobs recently let, the combined bid of a contractor whose job last season was speeded up by the bureau was $96,000 below that of the next lowest bidder.

THINNER BRICK FOR PAVING

Another investigation that has produced results of immediate value is the study of the relative resistance to traffic of pavements built of five thicknesses of paving brick. For a long time it has been the standard practice in brick-pavement construction to use brick approximately 4 inches thick. Lately in some sections of the country there have been trials of thinner brick, some of them involving the use of brick as thin as 2½ inches. Although the behavior of these trial sections has been almost uniformly satisfactory, engineers have been reluctant to adopt the thinner brick because of doubt as to their performance under conditions differing from those of the southwestern section in which practically all the trials have been made. Lack of confidence in the ability of the thinner brick to withstand the heavy pounding of truck wheels equipped with nonskid chains has been one of the reasons which have prevented engineers generally from availing themselves of the obvious opportunity to save expense; and this fear has been especially strong in the Northern States in which in winter it is not uncommon for heavy vehicles equipped with chains to be

confined in their operation to a single path by snow ruts. This is perhaps the most severe condition of use to which any pavement is ever subjected.

To resolve these doubts and to determine definitely just what minimum thickness of brick can be expected to give satisfactory service the bureau constructed a circular pavement at Arlington, Va., paved in several sections with brick of 2, 2½, 3, 3½, and 4 inch thickness. These it subjected to a controlled traffic of motor trucks both with and without chains until the equivalent of 18 or 20 years of normal traffic had been applied. The result is a conclusive proof of the adequacy of 2½-inch brick, which will be generally accepted and thus lead to a large annual saving in the cost of brick pavements.

Certain results of the motor-truck-impact tests also have immediate usefulness, especially those which indicate the effect of the kind and condition of tires used. This information should lead at once to the development of tire equipment which will be less destructive to the road surface. In this investigation the bureau has had the hearty cooperation of the Society of Automotive Engineers and the Rubber Association of America, and results of the highest importance to all groups interested have been obtained.

IMPORTANCE OF TRAFFIC SURVEYS

Extensive, state-wide surveys of highway utilization have been made in Connecticut, Maine, Pennsylvania, Ohio, California, and Cook County, Ill., and preparations are being made for similar surveys in New Hampshire and Vermont.

The evidence developed by these surveys as to the weight and volume of traffic in all parts of the State highway systems is of the utmost practical importance to the highway authorities of the States. The traffic-flow maps developed present a graphic picture of the relative importance of the various roads included in the system which enables those in charge of highway administration to prepare a really scientific budget and to design with practical certainty the improvement of the various parts of the system, scheduling such improvement in the order indicated by the volume and importance of the traffic.

Not until these surveys were made has any highway official had for his guidance such exact information. In the face of it clashing opinions and political pressure lose their power to sway the course of improvement, and the highway program is placed solidly upon a scientific basis. This is the immediate result; the less direct benefits which result from the gradual accumulation of basic facts leading to the development of the economic laws of highway transportation are no less important.

What is the economic field of the motor truck? To what degree does it compete with the railroads? To what extent is such competition desirable? What is the economic range of highway travel? What part of the movement is an interstate movement? Is or is not highway improvement actually justified by traffic savings? These and other questions of a similar character demand answers; and the bureau's surveys are supplying the basic facts upon which these answers will finally be formulated. It may almost be said that the bureau and its cooperators alone are carrying on this important work.

Typical of such long-time investigations is the painstaking work that is being done in the study of the characteristics of soils as highway subgrades. The variety of soils is limitless. Uniformity of subgrade support is the aim. How to deal with so wide a variety of materials and produce a condition of uniformity, or failing this, make suitable correction of the pavement or surface is a problem to which there is no hope of immediate solution.

Those who are working in this very important field are urged less by the hope of finding a final solution than by the passion of the scientist for facts. By unremitting careful work they are gradually piling up observation upon observation from the analysis of which a solution will finally be obtained, but of this there is no present prospect. The bureau is a pioneer in this field.

Of similar character are the various researches conducted independently and in cooperation with universities which have for their purpose the measurement of stresses in concrete under impact and static loads and also those resulting from variation in temperature or moisture. Important fundamental facts have been produced by such investigations conducted at Purdue and Johns Hopkins.

A method has been developed by which the load-carrying capacity of concrete pavements can be determined in a few hours by a single field test. Such a test made in Cook County, Ill., demonstrated that the heaviest pavement design provided by the county was just sufficient to carry the heaviest load permitted under the law. A simi-

lar demonstration in another State showed that the design of pavement adopted was not adequate for the loads legally permitted.

There has been a demand from legislators and from designing engineers for information on the relative effect upon the pavement of 6 and 8 wheel trucks and busses in comparison with the usual 4-wheel vehicles. To supply this needed information the bureau undertook and completed a series of tests which have demonstrated that a much larger gross load can be carried on a 6 or 8 wheel vehicle than on a 4-wheel vehicle with no greater harm to the pavement.

One of the outstanding engineering accomplishments of the day is the successful construction of the largest single-span suspension bridge in the world across the Delaware River at Philadelphia. A concrete highway 57 feet wide passes over this bridge. Obviously this concrete floor must be very strong yet comparatively light.

In order to be sure that the 6-inch slab designed for this purpose would be amply strong, the Delaware River Bridge Joint Commission requested the Bureau of Public Roads to make static-load and impact tests on a floor slab identical in design with those of the bridge.

Such tests have been made and have shown that the design which is unusually light and inexpensive is of sufficient strength to carry any load or impact to which it can legally be subjected. Aside from the immediate value of this information there is the more general benefit which will result from the use of this economical design, now proved to be ample, on other bridges.

In an effort to find the cause and suggest a remedy for the disintegration of concrete structures resulting from weather action a comprehensive series of freezing and thawing tests has been instituted, the results of which to date point to the necessity of certain precautions. Such precautions duly taken, it is expected will prevent a considerable loss in highway and other concrete structures.

In come sections of the country it has been necessary to spend hundreds of thousands of dollars to repair damage to highways by landslides. A field study of the conditions surrounding these slides is being made with a view to devising efficient means for their prevention. Already, in some cases, it has been possible to suggest remedies which will probably prevent further trouble.

Another of the important studies now being conducted is that relating to the stability of bituminous paving mixtures. By means of a circular test road on which various mixtures have been subjected to traffic, and by special tests conducted in the laboratory, an effort is being made to discover the laws which govern the stability of the mixtures. The information sought in these studies is of a fundamental nature and it is hoped that it will result in the development of a design for bituminous pavements which will not rut or wave. If successful, this investigation will result in great economies in bituminous pavement construction.

COOPERATIVE INVESTIGATIONS

Among the cooperative investigations in which the bureau is working with various universities and State highway departments are several of which the aim is to develop a suitable type of cheap surface for rural highways. At the University of Georgia combined laboratory and field investigations are being made to improve the service value of sand-clay and topsoil roads. The Iowa and South Dakota highway departments are endeavoring to develop a method of improving the service of earth roads by incorporation of lime and Portland cement; and in South Carolina experiments are being made with a view to preserving earth roads by applications of bituminous materials. The importance of these investigations, in view of the fact that millions of miles of roads throughout the country must long remain unpaved, can not be overemphasized.

Other cooperative investigations continued during the year include the tests made by the Iowa State College to determine the tractive resistance of various types of highway surface, those made at the Kansas Agricultural College to measure the wind resistance of automobiles, and those conducted at the University of Kansas for the purpose of measuring tire wear on various surfaces and pavements.

In addition to the research work of which that described is the most important, the bureau also carries on continuously a routine examination of highway materials mainly for the purpose of checking the work and thus controlling the large number of State and commercial laboratories upon whose tests the acceptance of materials used in Federal-aid road construction depends. The results of this work are evident in a general improvement of all laboratories and both Federal-aid and

State-highway construction have benefited by it.

In this connection the bureau has made numersous improvements in testing instruments and apparatus as well as in the methods of testing which have been generally adopted.

ORGANIZATION OF THE HIGHWAY FORCE OF THE BUREAU OF PUBLIC ROADS

The organization of the highway force of the Bureau of Public Roads which is responsible for the work reported upon in this report consists of a headquarters staff of eight divisions under the chief of bureau in the Washington office. Three of these, the divisions of design, construction, and bridges, constitute the staff which under the chief engineer and chief of bureau are responsible for the conduct of the Federal-aid and forest-road work. The division of control is responsible for all accounting, for statistics and records, and for investigations dealing with the economy and efficiency of road construction. The division of tests and research carries on all physical researches and makes routine tests of highway materials. The division of highway transportation and economics conducts research along economic lines with particular reference to the economics of highway transportation. In addition there are the legal and editorial divisions performing obvious functions.

In addition to this headquarters staff there is a field force through which direct contact is maintained with the several States in all matters relating to the Federal-aid and forest-road work. This force is headed by 11 district engineers with offices in Troy, N. Y.; Washington, D. C.; Montgomery, Ala.; Chicago, Ill.; St. Paul, Minn.; Omaha, Nebr.; Fort Worth, Tex.; Denver, Colo.; Ogden, Utah; Portland, Oreg.; and San Francisco, Calif. The eight eastern districts report directly to the chief engineer at Washington; those with headquarters in Denver, Portland, and San Francisco report to the deputy chief engineer, whose headquarters are in San Francisco, and through him to the Washington office.

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., September 1, 1927.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1927, covering the work done in connection with the construction of Federal-aid and national-forest roads and the economic and physical researches made in the highway field. A report of the work done by the agricultural engineering division of the bureau is submitted separately.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

Hon. W. M. JARDINE,
Secretary of Agriculture.

Through the Bureau of Public Roads, the Department of Agriculture cooperated during the past year with the highway departments of the several States and Hawaii in the construction of more than 8,300 miles of the Federal-aid highway system not previously improved with Federal assistance; and completed secondary improvements, necessitated by increased traffic, on 1,376 miles additional.

Independently, for the most part, it completed the construction of 453 miles of main highways in the national forests; and at the request of the National Park Service it surveyed and supervised the construction of important roads in the national parks and monuments, among them a number which will give access to hitherto unapproachable beauty spots of the national domain.

In cooperation with the State governments it completed the selection of the principal transcontinental roads which will form the United States highway system, and arranged for the uniform marking of these important arteries in all States as an aid to interstate travelers.

Continuing the distribution of war materials released by the War Department, it brought to practical completion this work begun shortly after the close of the World War. The wide variety of useful road material thus turned over to the State highway departments has served materially to advance the progress of road improvement in all States, and, especially, to preserve the roads constructed in a number of States in which the equipment necessary for efficient maintenance was lacking. Of the originally large and varied assortment of material available only a small quantity of explosives now remains to be distributed, and this distribution will be completed during the next 12 months. The value of the material distributed, exclusive of explosives, is estimated as approximately $242,500,000. The explosives distributed to June 30, 1927, are valued at about $18,600,000, making the total estimated value of material distributed to date approximately $261,100,000. Of this total, material valued at about $224,600,000 has been transferred to State highway departments; the amount used by the Department of Agriculture and other Government agencies is approximately $27,000,000, and the explosives made available to farmers have been valued at approximately $9,500,000.

Equaling, if not transcending, in value the services thus directly rendered in the construction of roads, the researches of the bureau have made available to engineers more exact knowledge of the fundamentals of highway design and economics. Of

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special importance are the studies of the magnitude and effects of the impact of heavy motor trucks upon highway surfaces, and the possibility of reducing the intensity of the impact forces by changes in the spring, wheel, and tire equipment of vehicles, and by refinements in the surface finish of roads.

Of fundamental importance, also, are the studies of soils with respect to their ability to support the loads of vehicles transmitted to them by pavements and road surfaces of various types; and the highway transport surveys conducted in a number of States and completed in several during the past year. These surveys, by developing exact information with regard to the volume of traffic using all sections of the highway system of a State provide a basis for a scientific administration of highway construction impossible without such knowledge.

Extending the methods of scientific study to the analysis of road-building operations, the bureau has been able to develop certain definite principles concerning the adjustment of labor and equipment and the utilization of both in the performance of various processes which, when applied by its own engineers and by contractors, have effected material reductions in cost, amounting in some cases to 50 per cent or more.

The results of these and similar investigations, disseminated in publications of the department and by addresses before bodies of engineers and contractors, are eagerly sought by road builders in the United States and throughout the world and, widely applied, have a multiplied effect of tremendous value.

The training of selected engineering students employed during the summer before graduation as assistants in the research work of the bureau, and subsequently on a full-time basis as apprentice engineers, is another means that has been adopted for the dissemination of the more exact knowledge resulting from research. Initiated for the purpose of supplying trained assistants to be employed in the construction work of the bureau, it is now found that the training may be offered to a larger number than has hitherto been possible, and this is being done in the belief that the body of specially trained young engineers will find employment in the service of the State highway departments as well as the bureau.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

The Federal-aid road projects completed during the fiscal year increased the mileage of improved roads in the Federal-aid highway system by 8,306.9 miles, bringing the total length of roads improved with Federal assistance up to 64,209.7 miles.

At the close of the year construction was in progress on 10,103 miles, and projects involving the improvement of 2,395.6 miles additional had been approved. Including the mileage of projects in these latter stages, all of which is included in the Federal-aid system, the total improved or in process of improvement with Federal aid at the close of the year was 76,708.3 miles. With the exception of a few hundred miles improved prior to the designation of the Federal-aid highway system in 1921, all of this mileage is included in the system.

The Federal-aid highway system now includes 185,772.2 miles of road selected by the constituted State and Federal highway officials as of primary importance for the accommodation of interstate highway traffic. Compared with the 3,000,000 miles of other highways in the United States, they are the most important of the Nation's highways, and their improvement as expeditiously as possible is an economic necessity of the highest importance.

Approximately a third of the system has already been improved with Federal assistance, and, with the exception of 7,469 miles, the 64,209.7 miles now reported as completed have been built in the six years since 1921. To this mileage the roads at present under construction and definitely planned will add nearly 12,500 miles.

With minor exceptions, the roads included in the Federal highway system are also parts of the several State highway systems, and are therefore eligible for improvement by the States alone under State legislation providing for such work.

For several years the unaided efforts of the States have resulted in the improvement of a greater mileage than has been built with Federal aid, and the major portion of this unaided State work has been applied to the improvement of the roads of the Federal-aid system. In the fiscal year 1926 the highways thus independently improved by the States aggregated approximately 12,500 miles; those improved with Fed-

eral aid totaled 10,610 miles. As appears from Table 1, the independent State work tends to increase, and for each mile improved with Federal cooperation there are now nearly 2 miles that are built by the States alone.

TABLE 1.—*Federal-aid mileage completed during the fiscal year 1927, including original and stage construction, compared with the total mileage completed in 1926 by State highway departments.*

Group of States	Federal-aid mileage (original and stage construction) completed, fiscal year 1927	Mileage completed by State highway departments, 1926	Ratio of Federal-aid to State program
			Per cent
New England	211.3	813.1	26.0
Middle Atlantic	489.5	1,680.0	29.1
South Atlantic	1,115.7	3,382.6	32.9
East North Central	714.4	4,644.7	15.4
West North Central	3,905.6	8,290.4	47.0
East South Central	585.1	1,987.7	29.4
West South Central	1,148.9	2,874.0	40.0
Mountain	1,146.4	2,113.1	54.3
Pacific	360.1	766.7	47.0
Total	9,677.0	26,552.3	36.4

The number of motor vehicles in use continues to increase annually at an approximately constant rate. The registration of 1926 was more than twice that of 1921, the year in which the Federal-aid system was designated, and the traffic served by the roads has, of course, increased proportionately. It is necessary, therefore, not only to extend the improved mileage but also gradually to raise the type of improvement on the roads already constructed as the demands of the traffic increase.

Of the Federal-aid roads already constructed amounting to 64,041.9 miles, as previously stated, 10,798.9 miles, largely in the Southern and Western States, are unsurfaced, the improvement consisting merely of the proper grading and draining of the roadbed. An additional large mileage is surfaced with inexpensive sand-clay and gravel. The improvement of these roads has been planned to meet the current requirements of the traffic and those of the immediate future. They are being faithfully maintained by the States under the constantly increasing usage, but there comes a time when maintenance of the lower form of improvement becomes more expensive than the construction of a higher form, and in recognition of this fact the Government, within the limits established by law, is cooperating with the States each year in the further improvement of roads previously built with Federal assistance.

During the fiscal year just ended the roads thus further improved have reached a total of 1,376.6 miles. This work, involving the construction of gravel surfaces on 989.6 miles and of 281.4 miles of concrete paving, with lesser mileages of other types, is not represented in the 8,306.9 miles reported as improved during the year, all of which were originally improved, nor does it add to the total of 64,041.9 miles improved up to the close of the year. From the standpoint of the year's work, however, and as improving the standard of service offered to traffic, it does constitute an important accomplishment. Adding this mileage to the mileage initially improved during the year, the total of all roads built is increased to 9,677 miles.

TYPES OF FEDERAL-AID ROADS

The 8,306.9 miles initially improved during the year include 2,537.1 miles of roads graded and drained, 612.1 miles surfaced with sand-clay, 2,309.5 miles surfaced with gravel, 137.1 miles of water-bound macadam, 462.7 miles of bituminous macadam, 159.9 miles paved with bituminous concrete, 2,002.7 miles with concrete, and 39.8 miles paved with vitrified brick. The remaining 45.9 miles were made up of bridges, all more than 20 feet in length.

As in previous years, the earth, sand-clay, and gravel constructed were mainly in the Southern and Western States. Of the 5,458.7 miles of these three types only 157.7 miles were in the States north of the Potomac and Ohio and east of the Mississippi. The small mileage of water-bound macadam was mainly in the four States of Georgia, Indiana, Ohio, and Texas, and the several higher types of construction, including bituminous macadam and better were built in all sections, constituting the highest percentages of the total, however, in the Northern and Eastern States where traffic is heaviest.

As shown by Table 2, there is an appropriate relation between the types of surfacing in the several geographic sections and what may be termed the potential motor-vehicle traffic as represented by the ratio of motor-vehicle registration to the mileage of the Federal-aid system in each section.

In this table the geographic divisions are arranged in the descending order of the ratio of their motor-vehicle registration to the mileage of the system, and it will be observed that, with the exception of the Pacific group, the several divisions would be rated in substantially the same order on the basis of their percentage of mileage suitable for medium and heavy motor-vehicle traffic. In the Pacific States the rather high percentage of the lower types is due to the construction of very considerable mileages of fine-crushed rock and gravel roads, a type not extensively built in other parts of the country but peculiarly adapted to the necessities of the far Western States in which the problem of improving a very large mileage in a reasonable time can be dealt with in no other way. Much of the mileage thus constructed will be conserved until funds are available for further improvement by oil treatment—a process which experience has shown is capable of producing very satisfactory results.

TABLE 2.—*Relation of potential motor-vehicle traffic and types of Federal-aid roads completed to June 30, 1927*

Group of States	Number of motor vehicles per mile of Federal-aid system [1]	Percentage of mileage of roads completed	
		Bituminous macadam and higher types	Water-bound macadam and lower types
Middle Atlantic	363	96.4	3.6
New England	233	71.0	29.0
Pacific	209	35.7	64.3
East North Central	193	71.3	28.7
South Atlantic	96	39.8	60.2
West South Central	81	23.8	76.2
East South Central	69	27.6	72.4
West North Central	66	15.4	84.6
Mountain	34	9.3	90.7
All States	118	32.7	67.3

[1] As registered in the several States during the calendar year 1926.

The wide range in traffic density in various parts of the country is indicated by the spread between the 363 vehicles per mile of Federal-aid system in the Middle Atlantic States and the corresponding ratio of 34 in the Mountain States. East of the Mississippi and north of the Ohio and the Potomac the average number of motor vehicles per mile of the system exceeds 200; in the rest of the country it is less than 100. This is a measure of the relative traffic requirements of the two broad regions, and it will be observed that the percentages of high and low types of improvement are in accord with these requirements.

LOW-TYPE HIGHWAYS FURTHER IMPROVED

The further improvement of the 1,376.6 miles of previously constructed low-type Federal-aid highways is in accordance with the agreements entered into by the States and the Government at the time these highways were originally improved. The original improvement was regarded as merely the first stage of a progressive improvement to be carried out as traffic requirements dictated and funds became available.

Nearly three-quarters of the mileage on which this further work was completed during the year was formerly improved as graded and drained earth road and has now been surfaced with gravel. Most of the rest of the 1,376.6 miles consists of roads on which a former gravel surface has been replaced by a higher type of surfacing or pavement.

This secondary construction completed during the year consisted in detail of 21 miles of roads graded and drained, 989.6 miles to which a gravel surface was applied, 20.3 miles surfaced with water-bound macadam, 25.6 miles on which a bituminous macadam surface was substituted for one of lower type, and the construction of 38.7 miles of bituminous concrete and 281.4 miles of Portland-cement concrete pavements, making a total of 1,376.6 miles, which is subdivided by States in Table 16.

The effect of this secondary construction is to raise the general level of improvement of the Federal-aid system very materially. As shown by Table 3, the mileage of graded and drained earth road at the close of the preceding year was 9,653.7 miles. This was increased by only 1,145.2 miles during the last year, although the mileage of such roads newly built during the year was 2,537.1 miles.

TABLE 3.—*Mileage of Federal-aid highways at the close of the fiscal years 1926 and 1927 and percentage of increase*

Type	Mileage at close of fiscal year 1926	Mileage at close of fiscal year 1927	Percentage increase during fiscal year 1927
Graded and drained	9,653.7	10,798.9	12.8
Sand-clay	4,926.2	5,721.7	16.0
Gravel	22,547.3	25,547.5	13.3
Water-bound macadam	1,123.3	1,309.9	16.7
Bituminous macadam	3,176:3	3,680.0	16.0
Bituminous concrete	1,626.1	1,818.9	11.8
Portland-cement concrete	11,976.6	14,391.2	20.2
Brick	752.0	773.8	3.0
Total	55,781.5	64,041.9	14.8

Similarly, although the mileage of the three lowest types of construction—earth, sand-clay, and gravel—newly constructed during the year was 5,458.7 miles, or 66 per cent of the total mileage of roads built, the mileage of these types in the portion of the system improved with Federal aid increased by only 4,940.9 miles, or less than 60 per cent of the net increase in improved mileage.

The types of road least suitable for motor-vehicle traffic are the graded and drained earth roads and those surfaced with sand-clay and water-bound macadam; those best adapted to such traffic are the bituminous concrete, Portland-cement concrete, and brick pavements. In view of the continuing increase in motor-vehicle registration and the corresponding increase in motor traffic throughout the country, it is interesting to observe from Table 3 that the increase in the mileage of the three lower types during the year was only 25.8 per cent of the total increase in mileage, although these same types constitute 39.8 per cent of the newly completed mileage.

The net increase of the types most suitable for motor-vehicle traffic was 31.9 per cent, although the newly constructed mileage of these types was only 26.7 per cent of the total new mileage. The gravel type, which is the cheapest type capable of resisting moderate motor-vehicle traffic and the usual choice for the secondary improvement of earth roads, increased 36.4 per cent in net mileage, although in the new construction it constituted only 28 per cent. These differences between the new construction and net increases of the several types reflect the beneficial results of stage construction.

The mileage of roads under construction and approved for construction at the end of the year is approximately the same as at the close of the preceding year, indicating that progress during the fiscal year 1928 will be practically the same as during the year just passed.

BRIDGE BUILDING INCREASES

The bridges completed during the fiscal year have an aggregate length of 45.9 miles, which is more than twice the mileage completed during the preceding year. Bridges under construction and approved for construction have an aggregate length of 64.5 miles, exceeding by 5.4 miles the total length of structures in the corresponding stages of progress at the beginning of the year.

Including the structures just completed, the Federal-aid bridges now standing have a total length of 167.6 miles, over a fourth of which was added during the last year.

All of these structures are more than 20 feet in span, and one, completed during the year, is more than two miles in length. This is the bridge over the Choctawhatchee River in Florida on the road between Westville and Careyville. Two others completed during the year are more than a mile in length. One of these, the bridge over the east fork of the White River on the road between Bedford and Mitchell in Indiana, is 1.4 miles long; the other, spanning the Platte River in Nebraska, is 1.1 miles in length.

Other outstanding bridges recently opened to traffic are the bridge over the Alabama River near Montgomery, Ala.; the American River bridge at Sacramento, Calif.; the structure spanning Pass Manchac on the road between New Orleans and Hammond, La.; and the Willamette River bridge at Harrisburg, Oreg.

A list of the bridges completed during the year which cost $75,000 or more is given in Table 4. These, the longest structures completed, vary in length from a tenth of a mile to more than 2 miles and have an aggregate length of 9.7 miles, which is only about a fifth of the total length of the structures completed during the year. The remainder is made up of numerous smaller and less expensive bridges.

TABLE 4.—*Federal-aid bridges completed during the fiscal year 1927 at a cost of $75,000 or more each*

State	Location	Stream	Length
			Miles
Alabama	Between Montgomery and Prattville	Alabama River	0.4
California	Between Montebello and Whittier	San Gabriel River	.1
Do	Between Red Bluff and Oregon State Line	Doney Creek	.1
Do	At Sacramento	American River	.6
Colorado	At Alamosa	Rio Grande del Norte	.2
Florida	Between Westville and Careyville	Choctawhatchee River.	2.2
Georgia	Between Savannah and Darien	Ogeechee River	.3
Idaho	At Salmon	Salmon River	.2
Indiana	Between Bedford and Mitchell	White River, East Fork.	1.4
Louisiana	Between Hammond and New Orleans	Pass Manchac	.5
Minnesota-North Dakota.	Between Pembina, N. Dak., and St. Vincent Minn.	Red River of the North.	.3
Missouri	Between St. Joseph and Bayfield	Platte River drainage ditch.	.1
Montana	At Glendive	Yellowstone River	.3
Nebraska	Between Yutan and Millard	Platte River	1.1
North Carolina	Between Charlotte and Wilmington	Pee Dee River	.3
Oklahoma	Between Harrah and Meeker	North Canadian River	.2
Oklahoma-Texas	Between Hugo, Okla., and Arthur City, Tex	Red River	.2
Oregon	At Albany	Willamette River	.2
Do	At Harrisburg	do	.4
Texas	At La Grange	Colorado River	.3
Do	Between Hearne and Gause	Brazos River	.2
Washington	Between Skokomish Indian Reservation and Bremerton.	Skokomish River	.1
Total			9.7

It is to be hoped that the increase in Federal-aid bridge construction evident in the mileage recently completed and under construction will continue, and that to a greater degree the States will resort to this means of reducing the local expense of large bridge structures rather than the distinctly objectionable means of permitting such important structures to be privately financed.

The bridges are essential parts of the Federal-aid system. Congress has given abundant evidence of its intention that this interstate system shall, so far as possible, be free for the use of the citizens of all States, by forbidding the collection of tolls on all roads in the construction of which the Government participates and by prohibiting the use of Federal funds for the improvement of roads which constitute the immediate approach to toll bridges.

The act passed at the last session which permits the financing of the State's portion of the cost of Federal-aid bridges by means of tolls collected by the State or its subdivisions removes the last reasonable excuse for permitting expensive bridges to be built by private initiative.

The large earnings of toll bridges on important highways are made possible by the public improvement of the highways. The very great attractiveness of such bridges to private investors is proof of the high return upon the capital invested. It is common knowledge that the entire cost of many expensive and important structures operated privately has been repaid by the tolls charged in a very few years, leaving the subsequent earnings, less a small amount for maintenance, as clear profit.

There seems to be no good reason why the States should not avail themselves of the recent Federal concession, permitting, as it does, the payment of a full 50 per cent of the cost of the bridges from Federal funds and the financing of the remainder on the basis of tolls publicly collected. Certainly it would seem that the new provision of law removes the principal condition which hitherto has given some measure of justification to private toll-bridge franchises, i. e., the impracticability of devoting the large sum of State money required for the construction of a large bridge to an improvement of such limited extent, for it is now possible for the State to finance its portion of the cost without using any part of the regular highway revenue.

THE COST OF THE ROADS

The total cost of the 8,306.9 miles of original construction and the 1,376.6 miles of stage construction completed during the year was $182,770,089.53, of which the Federal Government paid

$81,330,357.82, or 44.5 per cent, and the States the balance. These expenditures were made over the period required to construct the roads brought to completion during the year, which was approximately two years, and during the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal-aid funds during the year was $81,371,013.03, as shown in Table 5. This is a reduction of about $6,000,000 below the disbursement of the preceding year, which, in turn, was $8,000,000, less than the disbursement of the year before. As stated in the report a year ago, it may be expected that the annual expenditure will be still further reduced in the future until—the accumulated balances of earlier appropriations being expended—the program of expenditure reaches the rate set by the annual authorization of $75,000,000 of recent years.

The largest disbursements during the year were made to Missouri, New York, and Texas. To each of these States the Federal Government paid during the year more than $4,000,000. Pennsylvania received more than $3,000,000 and all other States received less than that amount.

In proportion to the total road mileage of the several geographic divisions, the Federal-aid disbursement in 1927 was greatest in the Middle Atlantic States and least in the West South Central States. On this basis the first of these two groups received more than twice as much as the second, and between these two extremes the other areas, ranked in descending order, were as follows: New England, South Atlantic, Pacific, East North Central, East South Central, West North Central, and Mountain.

TABLE 5.—*Federal-aid disbursements to States, fiscal year 1927*

States	Federal-aid disbursement	States	Federal-aid disbursement
Alabama	$1,206,220.03	New Hampshire	424,768.85
Arizona	721,244.42	New Jersey	732,592.69
Arkansas	986,717.98	New Mexico	1,110,390.27
California	2,978,864.97	New York	4,367,134.87
Colorado	1,289,506.73	North Carolina	2,441,688.30
Connecticut	613,841.51	North Dakota	2,530,261.21
Delaware	450,337.15	Ohio	2,580,502.50
Florida	1,434,043.79	Oklahoma	1,339,252.44
Georgia	2,535,285.99	Oregon	1,301,855.33
Idaho	1,235,844.70	Pennsylvania	3,180,313.25
Illinois	2,427,392.92	Rhode Island	466,586.24
Indiana	2,055,735.74	South Carolina	1,187,023.41
Iowa	2,845,968.50	South Dakota	1,074,687.39
Kansas	2,730,002.55	Tennessee	1,793,804.55
Kentucky	1,420,029.31	Texas	4,710,228.42
Louisiana	1,124,562.53	Utah	830,082.69
Maine	878,953.95	Vermont	625,423.73
Maryland	650,106.91	Virginia	1,868,896.29
Massachusetts	799,464.35	Washington	1,146,672.36
Michigan	2,692,098.35	West Virginia	648,202.63
Minnesota	2,590,339.01	Wisconsin	2,357,068.54
Mississippi	1,589,120.64	Wyoming	696,804.42
Missouri	4,099,338.56	Hawaii	253,061.09
Montana	894,779.83		
Nebraska	2,370,258.28	Total	81,371,013.03
Nevada	1,083,652.86		

The annual highway bill of the country is in excess of a billion dollars, including all expenditures of the Federal, State, and county and other local governments, for construction, maintenance, and administration. Of this amount the Federal expenditure is less than 8 per cent, and the States alone spent, of their own funds, more than six times the amount they received from the Federal Government. It is apparent, therefore, that the Federal expenditure, at the current rate, is not extravagant, but is, in fact, extremely moderate in view of the large and growing interstate traffic.

That the offer of Federal aid has not induced the States to make expenditures in excess of those they would otherwise have made is indicated by the fact, as shown by Table 6, that in 1926 every State, with two exceptions only, made expenditures, some very large, in addition to those for the Federal-aid roads, the total of such additional expenditures being $452,798,000, or more than four times the amount spent to match Federal aid. These are State expenditures only.

They do not include the amounts spent by the counties independent of State control, which, doubtless, were practically equal to those of the States.

TABLE 6.—*Approximate disbursements by State highway departments in excess of expenditures for Federal-aid roads, calendar year 1926*

State	State disbursements for other than Federal-aid roads
Alabama	$7,479,000
Arizona	1,993,000
Arkansas	7,080,000
California	14,544,000
Colorado	3,472,000
Connecticut	9,729,000
Delaware	2,909,000
Florida	11,642,000
Georgia	4,158,000
Idaho	1,643,000
Illinois	20,112,000
Indiana	8,004,000
Iowa	10,660,000
Kansas	5,468,000
Kentucky	6,264,000
Louisiana	8,669,000
Maine	8,222,000
Maryland	8,631,000
Massachusetts	11,706,000
Michigan	20,334,000
Minnesota	11,521,000
Mississippi	2,079,000
Missouri	21,957,000
Montana	
Nebraska	2,647,000
Nevada	623,000
New Hampshire	2,535,000
New Jersey	21,325,000
New Mexico	2,012,000
New York	31,486,000
North Carolina	32,395,000
North Dakota	
Ohio	23,562,000
Oklahoma	6,434,000
Oregon	7,974,000
Pennsylvania	42,345,000
Rhode Island	2,385,000
South Carolina	5,846,000
South Dakota	2,932,000
Tennessee	9,316,000
Texas	9,365,000
Utah	1,188,000
Vermont	2,145,000
Virginia	7,226,000
Washington	5,334,000
West Virginia	16,458,000
Wisconsin	7,258,000
Wyoming	1,731,000
Total	452,798,000

The two States that made no expenditures for highway purposes other than for Federal-aid roads were Montana and North Dakota. In these States practically all road improvement, except that included in the Federal-aid program, is carried on under the control of the counties.

In growing proportion the funds with which the States carry on all work of road improvement are supplied by the users of motor vehicles. In 1926 the sum thus raised by motor-vehicle license fees and gasoline taxes was $474,304,078, exceeding by nearly $70,000,000 the total of the preceding year.

The State funds required to match a Federal appropriation of $75,000,000 a year in the proportions required by the Federal law amount to $67,090,520, which, as shown by Table 7, is raised seven times over by the motor-vehicle taxes. In fact, the motorists now contribute almost enough to finance the entire program of the States, including the State portion of the cost of the Federal-aid roads, and, as the registration of motor vehicles is still growing, it may be anticipated that the State and Federal-aid roads will be paid for in the future to an increasing degree by those who regularly use them.

TABLE 7.—*Comparison of State motor-vehicle revenues and funds required to match Federal appropriations*

States	State funds required to match Federal appropriation of $75,000,000 apportioned Dec. 31, 1926	Gross income from motor-vehicle license fees and gasoline taxes, calendar year 1926
Alabama	$1,547,220	$5,447,903
Arizona [1]	404,153	1,446,059
Arkansas	1,277,896	7,241,672
California [1]	1,652,178	24,979,356
Colorado [1]	1,078,045	3,599,128
Connecticut	472,685	8,910,040
Delaware	365,625	1,165,991
Florida	899,451	18,195,954
Georgia	1,979,209	9,034,865
Idaho [1]	629,984	2,508,147
Illinois [2]	3,154,429	14,047,208
Indiana	1,926,772	14,064,917
Iowa	2,044,999	15,050,843
Kansas	2,068,532	9,106,518
Kentucky	1,417,947	9,066,823
Louisiana	1,013,308	6,702,033
Maine	680,794	4,178,711
Maryland	635,119	5,222,122
Massachusetts [2]	1,089,100	13,077,857
Michigan	2,214,691	27,035,461
Minnesota	2,120,741	14,781,248
Mississippi	1,307,879	6,061,612
Missouri	2,405,175	13,564,170
Montana [1]	1,196,462	1,900,095
Nebraska	1,585,138	6,676,024
Nevada [1]	132,783	615,738
New Hampshire	365,625	2,479,487
New Jersey [2]	934,611	11,870,529
New Mexico [1]	684,218	1,276,594
New York [2]	3,635,217	28,786,421
North Carolina	1,713,356	17,186,473
North Dakota	1,194,951	2,566,574
Ohio	2,762,209	23,076,139
Oklahoma [1]	1,406,377	11,727,454
Oregon [1]	716,918	9,351,588
Pennsylvania	3,335,735	35,827,131

[1] States not on 50–50 basis on account of public lands and nontaxable Indian lands.

[2] No gasoline tax assessed.

TABLE 7.—*Comparison of State motor-vehicle revenues and funds required to match Federal appropriations*—Con.

States	State funds required to match Federal appropriation of $75,000,000 apportioned Dec. 31, 1926	Gross income from motor-vehicle license fees and gasoline taxes, calendar year 1926
Rhode Island	$365,625	$2,474,794
South Carolina	1,054,988	6,448,527
South Dakota [1]	973,507	4,353,938
Tennessee	1,614,766	7,443,820
Texas	4,497,272	19,589,769
Utah [1]	226,486	1,892,057
Vermont	365,625	2,249,675
Virginia	1,442,714	10,480,145
Washington [1]	949,255	9,538,096
West Virginia	793,636	6,651,610
Wisconsin	1,870,455	14,284,295
Wyoming [1]	521,034	1,068,467
Hawaii [2]	365,625	
Total	67,090,520	474,304,078

[1] States not on 50-50 basis on account of public lands and nontaxable Indian lands.
[2] No tax data available.

As shown by Table 7, every State has sufficient revenue from the taxation of motor vehicles to match the Federal contribution—most of them much more than enough. The Federal-aid roads, in general, are the most important roads in all States, i. e, they are used more extensively by motor-vehicle operators than other roads. Their improvement, by reducing the cost of vehicular operation and maintenance, benefits the users far beyond the amount of the taxes paid, and this fact is so clearly recognized by the motorists themselves that these particular taxes are paid more willingly, perhaps, than any others. It may be concluded, therefore, with positive assurance, that the expenditures for State and Federal-aid road improvement are in no considerable degree responsible for the complaint of burdensome taxation.

FEDERAL-AID APPORTIONMENT EQUITABLE

As stated in the report for the fiscal year 1926, the apportionment of Federal aid is quite consistent with the needs of the several sections of the country, as indicated by the ratio of motor-vehicle registration to the mileage of the Federal-aid system in each area. This ratio is a measure of potential traffic on the system, and, according as it is high or low, expresses the need for a higher or lower type of road improvement, i. e., for a greater or less expenditure.

A year ago it was shown that the total apportionment of Federal-aid appropriations to each of the several geographic divisions of the country, considering the mileage in each, was in remarkably close agreement with the requirements of traffic, as indicated by the ratio referred to above.

The changes in motor-vehicle registration in the last year and the appropriation that has since become available have not altered this very satisfactory relation. As shown by Table 8, the average Federal-aid apportionment per mile of system is still consistent with the potential traffic, as indicated by the motor-vehicle registration per mile. The several areas are arranged in the table in the descending order of their average Federal-aid apportionment per mile, and it will be seen that, with the exception of the East South Central and Mountain States, they would be ranked in the same order in respect to their potential traffic. The two exceptional groups are shown to have received a somewhat disproportionate apportionment in consideration of their potential traffic.

TABLE 8.—*Apportionment of Federal aid per mile of Federal-aid highway system compared with motor-vehicle registration*

Group of States	Mileage of Federal-aid system approved to June 30, 1927	Federal-aid funds apportioned to States July 11, 1916 to June 30, 1927	Motor vehicles registered during 1926	Average Federal-aid apportionment per mile of system	Motor vehicle registration per mile of system
Middle Atlantic	10,818.4	$81,756,959	3,922,033	$7,566	363
New England	5,917.7	33,352,257	1,378,721	5,636	233
Pacific	10,513.0	47,895,109	2,197,322	4,556	209
East North Central	27,945.9	123,478,085	5,404,142	4,418	193
East South Central	14,443.3	60,858,685	992,326	4,214	69
South Atlantic	21,728.3	90,172,875	2,093,402	4,150	96
Mountain	21,735.3	88,916,981	735,286	4,091	34
West South Central	24,676.6	86,084,797	1,998,726	3,489	81
West North Central	47,993.7	130,518,474	3,167,938	2,719	66
All States	185,772.2	[1] 743,034,222	21,889,896	4,000	118

[1] Including the apportionment of $1,465,778 to Hawaii the total apportionment up to June 30, 1927, was $744,500,000.

As a year ago, the greatest motor-vehicle registration per mile is in the Middle Atlantic States, and this group, including New York, Pennsylvania, and New Jersey, is also shown to have received the largest apportionment of Federal aid in proportion to the mileage of the Federal-aid system within their borders. Next to these States in order of potential traffic and also in the magnitude of the apportionment are the New England States.

The West North Central States' apportionment per mile of highway in the system is lower than that of any other group and their potential traffic is greater than that of only one other group.

SUMMARY OF FEDERAL-AID ROAD WORK BY STATES

The progress made in each of the States during the year and the results of the 11 years of Federal-aid road construction are set forth in the following condensed summary for each State.

ALABAMA

The Federal-aid highway system includes 3,884 miles, of which 1,494 miles have been improved with Federal aid. Of the improved mileage, 78.3 miles were added during the year. At the close of the year 299.9 miles were under construction and 1.9 miles were approved.

The mileage improved with Federal aid consists of 72.3 miles of graded and drained earth roads, 413.2 miles of sand-clay, 780.9 miles of gravel, 11.6 miles of water-bound macadam, 53.2 miles of bituminous macadam, 87.5 miles of bituminous concrete, and 71.9 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 3.3 miles.

The total cost of all Federal-aid roads completed, including 10.2 miles of stage construction, was $22,394,983.26, of which the Federal share was $10,678,040.69. The disbursement of Federal funds to the State was $1,206,220.03. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $15,896,675, leaves a balance of $4,771,272.49 unexpended funds to the credit of the State.

ARIZONA

The Federal-aid highway system includes 1,498 miles, of which 835.7 miles have been improved with Federal aid. Of the improved mileage, 68.6 miles were added during the year. At the close of the year 27.8 miles were under construction and 19.1 miles were approved.

The mileage improved with Federal aid consists of 124.2 miles of graded and drained earth roads, 131.4 miles of sand-clay, 428.2 miles of gravel, 14.2 miles of water-bound macadam, 26.6 miles of bituminous concrete, and 108.5 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.6 miles.

The total cost of all Federal-aid roads completed, including 7.1 miles of stage construction, was $12,288,747, of which the Federal share was $6,750,136.37. The disbursement of Federal funds to the State was $721,244.42. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,674,243, leaves a balance of $3,693,858.39 unexpended funds to the credit of the State.

ARKANSAS

The Federal-aid highway system includes 5,021.1 miles, of which 1,587.4 miles have been improved with Federal aid. Of the improved mileage, 168.9 miles were added during the year. At the close of the year 184.7 miles were under construction and 19.4 miles were approved.

The mileage improved with Federal aid consists of 3 miles of sand-clay, 1,059.5 miles of gravel, 48.4 miles of water-bound macadam, 98.9 miles of bituminous macadam, 256.3 miles of bituminous concrete, and 118.2 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 3.3 miles.

The total cost of all Federal-aid roads completed was $22,638,788.64, of which the Federal share was $9,675,983.97. The disbursement of Federal funds to the State was $986,717.98. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $12,883,700, leaves a balance of $2,794,443.71 unexpended funds to the credit of the State.

CALIFORNIA

The Federal-aid highway system includes 4,771.5 miles, of which 1,365.3 miles have been improved with Federal aid. Of the improved mileage, 195.6 miles were added during the year. At the close of the year 92.4 miles were under construction and 4.5 miles were approved.

The mileage improved with Federal aid consists of 314 miles of graded and drained earth roads, 348.5 miles of

gravel, 18.6 miles of water-bound macadam, 63.1 miles of bituminous macadam, 85.9 miles of bituminous concrete, and 530 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 4.9 miles.

The total cost of all Federal-aid roads completed, including 34 miles of stage construction, was $37,590,843.42, of which the Federal share was $18,275,-993.48. The disbursement of Federal funds to the State was $2,978,864.97. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $24,556,252, leaves a balance of $5,457,231.73 unexpended funds to the credit of the State.

COLORADO

The Federal-aid highway system includes 3,332 miles, of which 936.6 miles have been improved with Federal aid. Of the improved mileage, 166.6 miles were added during the year. At the close of the year 141.5 miles were under construction and 2.9 miles were approved.

The mileage improved with Federal aid consists of 231.7 miles of graded and drained earth roads, 105.7 miles of sand-clay, 409 miles of gravel, 4 miles of bituminous concrete, and 207.3 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 6 miles.

The total cost of all Federal-aid roads completed, including 5.3 miles of stage construction, was $18,184,354.89, of which the Federal share was $9,269,-990.10. The disbursement of Federal funds to the State was $1,289,506.73. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $13,702,332, leaves a balance of $4,283,337.09 unexpended funds to the credit of the State.

CONNECTICUT

The Federal-aid highway system includes 835.4 miles, of which 151.1 miles have been improved with Federal aid. Of the improved mileage, 24 miles were added during the year. At the close of the year 50.1 miles were under construction and 13 miles were approved.

The mileage improved with Federal aid consists of 0.2 mile of gravel, 8.7 miles of water-bound macadam, 27.1 miles of bituminous macadam, and 114.9 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 0.3 mile.

The total cost of all Federal-aid roads completed was $7,612,390.21, of which the Federal share was $2,691,-696.71. The disbursement of Federal funds to the State was $613,841.51. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $4,806,366, leaves a balance of $1,839,661.74 unexpended funds to the credit of the State.

DELAWARE

The Federal-aid highway system includes 415.8 miles, of which 164.5 miles have been improved with Federal aid. Of the improved mileage, 40.2 miles were added during the year. At the close of the year 27.9 miles were under construction and 11 miles were approved.

The mileage improved with Federal aid consists of 5 miles of water-bound macadam, 153.1 miles of Portland-cement concrete, and 6.2 miles of brick, in addition to which there are bridges with a total length of 0.2 mile.

The total cost of all Federal-aid roads completed was $6,350,437.65, of which the Federal share was $2,402,-277.97. The disbursement of Federal funds to the State was $450,337.15. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $2,839,683, leaves a balance of $472,267.59 unexpended funds to the credit of the State.

FLORIDA

The Federal-aid highway system includes 1,926 miles, of which 315.6 miles have been improved with Federal aid. Of the improved mileage, 65.9 miles were added during the year. At the close of the year 125.8 miles were under construction and 24.2 miles were approved.

The mileage improved with Federal aid consists of 9.8 miles of graded and drained earth roads, 21.1 miles of sand-clay, 34.8 miles of gravel, 18.5 miles of water-bound macadam, 72.7 miles of bituminous macadam, 41.8 miles of bituminous concrete, 103.9 miles of Portland-cement concrete, and 10.1 miles of brick, in addition to which there are bridges with a total length of 3 miles.

The total cost of all Federal-aid roads completed, including 24.8 miles of stage construction, was $10,391,903.41, of which the Federal share was $5,011,-696.35. The disbursement of Federal funds to the State was $1,434,043.79. This, added to the disbursements made

during previous years and subtracted from the State's total apportionment of $8,984,405, leaves a balance of $2,701,356.63 unexpended funds to the credit of the State.

GEORGIA

The Federal-aid highway system includes 5,558.4 miles, of which 2,369.8 miles have been improved with Federal aid. Of the improved mileage, 394.3 miles were added during the year. At the close of the year 137.5 miles were under construction and 0.3 mile was approved.

The mileage improved with Federal aid consists of 166 miles of graded and drained earth roads, 1,257.7 miles of sand-clay, 423.3 miles of gravel, 73.1 miles of water-bound macadam, 123.1 miles of bituminous macadam, 25.9 miles of bituminous concrete, 275.2 miles of Portland-cement concrete, and 0.5 mile of brick, in addition to which there are bridges with a total length of 25.2 miles.

The total cost of all Federal-aid roads completed, including 156 miles of stage construction, was $36,023,188.89, of which the Federal share was $17,101,498.97. The disbursement of Federal funds to the State was $2,535,285.99. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $20,411,162, leaves a balance of $2,435,761.10 unexpended funds to the credit of the State.

IDAHO

The Federal-aid highway system includes 2,770 miles, of which 950.7 miles have been improved with Federal aid. Of the improved mileage, 177 miles were added during the year. At the close of the year 83.9 miles were under construction and 9.3 miles were approved.

The mileage improved with Federal aid consists of 228.7 miles of graded and drained earth roads, 22.7 miles of sand-clay, 591.4 miles of gravel, 4.3 miles of water-bound macadam, 4.9 miles of bituminous macadam, 61 miles of bituminous concrete, and 35.9 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2 miles.

The total cost of all Federal-aid roads completed, including 83.5 miles of stage construction, was $14,160,210.06, of which the Federal share was $7,669,247.11. The disbursement of Federal funds to the State was $1,235,844.20. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $9,494,820, leaves a balance of $1,569,930.43 unexpended funds to the credit of the State.

ILLINOIS

The Federal-aid highway system includes 6,616.8 miles, of which 1,543.4 miles have been improved with Federal aid. Of the improved mileage, 76.3 miles were added during the year. At the close of the year 343.4 miles were under construction and 187 miles were approved.

The mileage improved with Federal aid consists of 110.4 miles of graded and drained earth roads, 3.3 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1,394.4 miles of Portland-cement concrete, and 25.8 miles of brick, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed, including 28.2 miles of stage construction, was $48,898,354.53, of which the Federal share was $22,958,520.84. The disbursement of Federal funds to the State was $2,427,392.92. This added to the disbursements made during previous years and subtracted from the State's total apportionment of $32,986,627, leaves a balance of $8,012,418.05 unexpended funds to the credit of the State.

INDIANA

The Federal-aid highway system includes 4,701.5 miles, of which 841.5 miles have been improved with Federal aid. Of the improved mileage, 154.3 miles were added during the year. At the close of the year 367.9 miles were under construction and 68.8 miles were approved.

The mileage improved with Federal aid consists of 17 miles of graded and drained earth roads, 33.5 miles of gravel, 56.7 miles of water-bound macadam, 17 miles of bituminous macadam, 12 miles of bituminous concrete, and 702.3 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.9 miles.

The total cost of all Federal-aid roads completed, including 11.6 miles of stage construction, was $27,496,654.62, of which the Federal share was $13,147,848.20. The disbursement of Federal funds to the State was $2,055,735.74. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $20,131,127, leaves a balance of $4,570,362.18 unexpended funds to the credit of the State.

IOWA

The Federal-aid highway system includes 7,212 miles, of which 2,592.6 miles have been improved with Federal aid. Of the improved mileage, 415.6 miles were added during the year. At the close of the year 456.6 miles were under construction and 44.1 miles were approved.

The mileage improved with Federal aid consists of 1,469 miles of graded and drained earth roads, 586.4 miles of gravel, 514 miles of Portland-cement concrete, and 22 miles of brick, in addition to which there are bridges with a total length of 1.2 miles.

The total cost of all Federal-aid roads completed, including 130.2 miles of stage construction, was $36,686,963.96, of which the Federal share was $15,507,575.57. The disbursement of Federal funds to the State was $2,845,968.50. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $21,530,562, leaves a balance of $4,882,751.15 unexpended funds to the credit of the State.

KANSAS

The Federal-aid highway system includes 7,892 miles, of which 1,624.7 miles have been improved with Federal aid. Of the improved mileage, 361.1 miles were added during the year. At the close of the year 555.1 miles were under construction and 167 miles were approved.

The mileage improved with Federal aid consists of 562.1 miles of graded and drained earth roads, 135.7 miles of sand-clay, 198 miles of gravel, 4.5 miles of water-bound macadam, 97.7 miles of bituminous macadam, 3.4 miles of bituminous concrete, 479.3 miles of Portland-cement concrete, and 134.4 miles of brick, in addition to which there are bridges with a total length of 9.2 miles.

The total cost of all Federal-aid roads completed, including 27 miles of stage construction, was $40,056,652.74, of which the Federal share was $15,781,141.51. The disbursement of Federal funds to the State was $2,730,002.55. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $21,532,943, leaves a balance of $4,130,152.52 unexpended funds to the credit of the State.

KENTUCKY

The Federal-aid highway system includes 3,702.5 miles, of which 898 miles have been improved with Federal aid. Of the improved mileage, 110.6 miles were added during the year. At the close of the year 393.4 miles were under construction and 42.8 miles were approved.

The mileage improved with Federal aid consists of 411.2 miles of graded and drained earth roads, 160.6 miles of gravel, 41.4 miles of water-bound macadam, 153.4 miles of bituminous macadam, 126.9 miles of Portland-cement concrete, and 3.9 miles of brick, in addition to which there are bridges with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed, including 111.3 miles of stage construction, was $24,510,594.46, of which the Federal share was $10,092,978.19. The disbursement of Federal funds to the State was $1,420,029.31. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $1,463,756, leaves a balance of $3,300,565.05 unexpended funds to the credit of the State.

LOUISIANA

The Federal-aid highway system includes 2,722.8 miles, of which 1,214.5 miles have been improved with Federal aid. Of the improved mileage, 144.7 miles were added during the year. At the close of the year 105.1 miles were under construction and 0.9 mile was approved.

The mileage improved with Federal aid consists of 25.2 miles of graded and drained earth roads, 1,152.1 miles of gravel, 3.2 miles of water-bound macadam, 9.5 miles of bituminous macadam, 10.4 miles of bituminous concrete, and 10.7 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 3.5 miles.

The total cost of all Federal-aid roads completed, including 4 miles of stage construction, was $16,906,801.67, of which the Federal share was $7,588,692.38. The disbursement of Federal funds to the State was $1,124,562.53. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,285,716, leaves a balance of $2,127,187.13 unexpended funds to the credit of the State.

MAINE

The Federal-aid highway system includes 1,393.5 miles, of which 362.8 miles have been improved with Federal aid. Of the improved mileage, 59.2 miles were added during the year. At the close of the year 69.6 miles were under construction and 5.6 miles were approved.

The mileage improved with Federal aid consists of 156 miles of gravel, 155.3 miles of bituminous macadam, and 51.4 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 0.2 mile.

The total cost of all Federal-aid roads completed was $10,663,734.80, of which the Federal share was $4,907,920.04. The disbursement of Federal funds to the State was $878,953.95. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $7,145,622, leaves a balance of $1,760,547.37 unexpended funds to the credit of the State.

MARYLAND

The Federal-aid highway system includes 1,503.7 miles, of which 481.8 miles have been improved with Federal aid. Of the improved mileage, 58.5 miles were added during the year. At the close of the year 29.9 miles were under construction and 66.6 miles were approved.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of gravel, 0.1 mile of water-bound macadam, 152.6 miles of bituminous macadam, 17 miles of bituminous concrete, and 276 miles of Portland-cement concrete.

The total cost of all Federal-aid roads completed was $11,924,475.65, of which the Federal share was $5,584,458.27. The disbursement of Federal funds to the State was $650,106.91. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $6,560,176, leaves a balance of $763,972.12 unexpended funds to the credit of the State.

MASSACHUSETTS

The Federal-aid highway system includes 1,308 miles, of which 440.7 miles have been improved with Federal aid. Of the improved mileage, 55 miles were added during the year. At the close of the year 62.6 miles were under construction and 2.3 miles were approved.

The mileage improved with Federal aid consists of 3.5 miles of water-bound macadam, 227.7 miles of bituminous macadam, 36.8 miles of bituminous concrete, and 168.2 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 4.3 miles.

The total cost of all Federal-aid roads completed was $22,960,850.63, of which the Federal share was $7,959,329.39. The disbursement of Federal funds to the State was $799,464.35. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $11,197,826, leaves a balance of $3,604,233.03 unexpended funds to the credit of the State.

MICHIGAN

The Federal-aid highway system includes 5,235 miles, of which 1,161.5 miles have been improved with Federal aid. Of the improved mileage, 165.9 miles were added during the year. At the close of the year 288 miles were under construction and 26.3 miles were approved.

The mileage improved with Federal aid consists of 0.5 mile of graded and drained earth roads, 329.9 miles of gravel, 18.9 miles of water-bound macadam, 10.4 miles of bituminous macadam, 73.5 miles of bituminous concrete, 727.7 miles of Portland-cement concrete, and 0.4 mile of brick, in addition to which there are bridges with a total length of 0.4 mile.

The total cost of all Federal-aid roads completed, including 42.4 miles of stage construction, was $34,875,126.43, of which the Federal share was $15,628,180.61. The disbursement of Federal funds to the State was $2,692,098.35. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $22,557,056, leaves a balance of $5,201,602.96 unexpended funds to the credit of the State.

MINNESOTA

The Federal-aid highway system includes 6,849.6 miles, of which 3,643.5 miles have been improved with Federal aid. Of the improved mileage, 394.3 miles were added during the year. At the close of the year 370 miles were under construction and 19.4 miles were approved.

The mileage improved with Federal aid consists of 490 miles of graded and drained earth roads, 6.2 miles of sand-clay, 2,630.1 miles of gravel, 32.6 miles of bituminous concrete, and 483.9 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed, including 296.1 miles of stage construction, was $45,099,-648.47, of which the Federal share was $19,046,145.67. The disbursement of Federal funds to the State was $2,590,339.01. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $21,712,521, leaves a balance of $2,189,305.45 unexpended funds to the credit of the State.

MISSISSIPPI

The Federal-aid highway system includes, 3,604 miles, of which 1,376.7 miles have been improved with Federal aid. Of the improved mileage, 217.8 miles were added during the year. At the close of the year 301.1 miles were under construction and 65.2 miles were approved.

The mileage improved with Federal aid consists of 213.9 miles of graded and drained earth roads, 21.5 miles of sand-clay, 976.6 miles of gravel, 11.1 miles of water-bound macadam, 1 mile of bituminous macadam, 9.5 miles of bituminous concrete, 133.1 miles of Portland-cement concrete, and 9.2 miles of brick, in addition to which there are bridges with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed, including 58 miles of stage construction, was $19,036,438.71, of which the Federal share was $9,356,898.57. The disbursement of Federal funds to the State was $1,589,120.64. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $13,435,897, leaves a balance of $2,726,597.67 unexpended funds to the credit of the State.

MISSOURI

The Federal-aid highway system includes 7,530 miles, of which 2,077.6 miles have been improved with Federal aid. Of the improved mileage, 281.9 miles were added during the year. At the close of the year 134 miles were under construction and 68.4 miles were approved.

The mileage improved with Federal aid consists of 340 miles of graded and drained earth roads, 867.4 miles of gravel, 13.4 miles of water-bound macadam, 50.9 miles of bituminous macadam, 17.8 miles of bituminous concrete, 757.7 miles of Portland-cement concrete, and 20.9 miles of brick, in addition to which there are bridges with a total length of 9.1 miles.

The total cost of all Federal-aid roads completed, including 69.7 miles of stage construction, was $47,057,-985.96, of which the Federal share was $21,442,541.23. The disbursement of Federal funds to the State was $4,099,-338.56. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $25,191,611, leaves a balance of $4,295,198.35 unexpended funds to the credit of the State.

MONTANA

The Federal-aid highway system includes 4,665 miles, of which 1,161.8 miles have been improved with Federal aid. Of the improved mileage, 90.3 miles were added during the year. At the close of the year 119.6 miles were under construction and 305.9 miles were approved.

The mileage improved with Federal aid consists of 213.1 miles of graded and drained earth roads, 5.6 miles of sand-clay, 883.7 miles of gravel, 16 miles of water-bound macadam, 6.9 miles of bituminous macadam, 2.8 miles of bituminous concrete, and 31.3 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.5 miles.

The total cost of all Federal-aid roads completed, including 71.5 miles of stage construction, was $12,937,675.16, of which the Federal share was $7,347,-567.20. The disbursement of Federal funds to the State was $894,779.83. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $14,976,384, leaves a balance of $7,198,788.68 unexpended funds to the credit of the State.

NEBRASKA

The Federal-aid highway system includes 5,569.1 miles, of which 2,651.1 miles have been improved with Federal aid. Of the improved mileage, 629.9 miles were added during the year. At the close of the year 900.6 miles were under construction and 166.6 miles were approved.

The mileage improved with Federal aid consists of 922.9 miles of graded and drained earth roads, 764.6 miles of sand-clay, 873.7 miles of gravel, 11 miles of bituminous concrete, 55 miles of Portland-cement concrete, and 18.7 miles of brick, in addition to which there are bridges with a total length of 5.3 miles.

The total cost of all Federal-aid roads completed, including 666.6 miles of stage construction, was $20,308,-791.23, of which the Federal share was $9,779,936.76. The disbursement of

Federal funds to the State was $2,370,258.28. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $16,220,373, leaves a balance of $4,986,183.13 unexpended funds to the credit of the State.

NEVADA

The Federal-aid highway system includes 1,398 miles, of which 940.7 miles have been improved with Federal aid. Of the improved mileage, 230.6 miles were added during the year. At the close of the year 95.6 miles were under construction.

The mileage improved with Federal aid consists of 40.6 miles of graded and drained earth roads, 26.4 miles of sand-clay, 792.9 miles of gravel, 10.2 miles of water-bound macadam, 20.6 miles of bituminous macadam, 2 miles of bituminous concrete, and 44.9 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 3.3 miles.

The total cost of all Federal-aid roads completed, including 76 miles of stage construction, was $11,049,750.51, of which the Federal share was $8,133,489.64. The disbursement of Federal funds to the State was $1,083,652.86. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $9,743,725, leaves a balance of $1,166,710.95 unexpended funds to the credit of the State.

NEW HAMPSHIRE

The Federal-aid highway system includes 980.9 miles, of which 268.5 miles have been improved with Federal aid. Of the improved mileage, 23.9 miles were added during the year. At the close of the year 27.1 miles were under construction and 8.8 miles were approved.

The mileage improved with Federal aid consists of 99.1 miles of gravel, 53.8 miles of water-bound macadam, 72.5 miles of bituminous macadam, 32.6 miles of bituminous concrete, and 7.7 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.6 miles.

The total cost of all Federal-aid roads completed was $5,966,371.13, of which the Federal share was $2,827,664.73. The disbursement of Federal funds to the State was $424,768.85. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $3,535,117, leaves a balance of $628,734.92 unexpended funds to the credit of the State.

NEW JERSEY

The Federal-aid highway system includes 1,198.3 miles, of which 345.1 miles have been improved with Federal aid. Of the improved mileage, 37.2 miles were added during the year. At the close of the year 82.5 miles were under construction and 5.9 miles were approved.

The mileage improved with Federal aid consists of 6.2 miles of graded and drained earth roads, 0.8 mile of sand-clay, 3.8 miles of gravel, 21.9 miles of bituminous concrete, and 310.1 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed was $24,357,307.14, of which the Federal share was $7,939,988.87. The disbursement of Federal funds to the State was $732,592.69. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $9,402,031, leaves a balance of $1,906,666.52 unexpended funds to the credit of the State.

NEW MEXICO

The Federal-aid highway system includes 3,298 miles, of which 1,560.3 miles have been improved with Federal aid. Of the improved mileage 69.8 miles were added during the year. At the close of the year 178.5 miles were under construction.

The mileage improved with Federal aid consists of 243.4 miles of graded and drained earth roads, 5.1 miles of sand-clay, 1,239.4 miles of gravel, 0.7 mile of bituminous concrete, and 70.1 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of all Federal-aid roads completed, including 93 miles of stage construction, was $13,993,014.03, of which the Federal share was $8,401,600.54. The disbursement of Federal funds to the State was $1,110,390.27. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $12,159,149, leaves a balance of $3,173,897.80 unexpended funds to the credit of the State.

NEW YORK

The Federal-aid highway system includes 5,018 miles, of which 1,479.8 miles have been improved with Federal aid. Of the improved mileage 248 miles were added during the year. At the close of the year 539.3 miles were under construction and 155.6 miles were approved.

The mileage improved with Federal aid consists of 2.4 miles of graded and drained earth roads, 22.8 miles of gravel, 345.1 miles of bituminous macadam, 11.5 miles of bituminous concrete, 1,096 miles of Portland-cement concrete, and 0.7 mile of brick, in addition to which there are bridges with a total length of 1.5 miles.

The total cost of all Federal-aid roads completed was $56,632,985.44, of which the Federal share was $22,425,513.15. The disbursement of Federal funds to the State was $4,367,134.87. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $37,680,412, leaves a balance of $12,635,971.33 unexpended funds to the credit of the State.

NORTH CAROLINA

The Federal-aid highway system includes 3,860.8 miles, of which 1,489 miles have been improved with Federal aid. Of the improved mileage 145.9 miles were added during the year. At the close of the year 58.7 miles were under construction and 36.8 miles were approved.

The mileage improved with Federal aid consists of 89.6 miles of graded and drained earth roads, 521.1 miles of sand-clay, 70.9 miles of gravel, 19.6 miles of water-bound macadam, 37.9 miles of bituminous macadam 249.4 miles of bituminous concrete, and 498.3 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed, including 91.8 miles of stage construction, was $36,025,574.41, of which the Federal share was $14,869,283.31. The disbursement of Federal funds to the State was $2,441,688.30. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $17,430,562, leaves a balance of $2,114,184.48 unexpended funds to the credit of the State.

NORTH DAKOTA

The Federal-aid highway system includes 7,194 miles, of which 2,851.7 miles have been improved with Federal aid. Of the improved mileage 576 miles were added during the year. At the close of the year 602.8 miles were under construction and 320.8 miles were approved.

The mileage improved with Federal aid consists of 1,458.6 miles of graded and drained earth roads, 25.1 miles of sand-clay, 1,354.3 miles of gravel, 1 mile of water-bound macadam, 1.9 miles of bituminous concrete, and 4.7 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 6 miles.

The total cost of all Federal-aid roads completed, including 840.8 miles of stage construction, was $16,716,504.05, of which the Federal share was $8,225,349.31. The disbursement of Federal funds to the State was $2,530,261.21. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $11,943,610, leaves a balance of $2,612,640.08 unexpended funds to the credit of the State.

OHIO

The Federal-aid highway system includes 5,899.3 miles, of which 1,550.7 miles have been improved with Federal aid. Of the improved mileage 128.1 miles were added during the year. At the close of the year 298.6 miles were under construction and 20.8 miles were approved.

The mileage improved with Federal aid consists of 41.2 miles of graded and drained earth roads, 6.7 miles of gravel, 103.3 miles of water-bound macadam, 320.1 miles of bituminous macadam, 93.8 miles of bituminous concrete, 539.9 miles of Portland-cement concrete, and 444.9 miles of brick, in addition to which there are bridges with a total length of 0.7 mile.

The total cost of all Federal-aid roads completed, including 34.6 miles of stage construction, was $53,799,465.23, of which the Federal share was $19,827,851.84. The disbursement of Federal funds to the State was $2,580,502.50. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $28,494,005, leaves a balance of $6,740,945.60 unexpended funds to the credit of the State.

OKLAHOMA

The Federal-aid highway system includes 5,528 miles, of which 1,384.5 miles have been improved with Federal aid. Of the improved mileage, 183 miles were added during the year. At the close of the year 134.8 miles were under construction and 71.5 miles were approved.

The mileage improved with Federal aid consists of 219.8 miles of graded and drained earth roads, 2.3 miles of sand-clay, 605.6 miles of gravel, 6.3 miles of water-bound macadam, 8.4 miles of bituminous macadam, 78.4 miles of bituminous concrete, 443 miles of Portland-cement concrete, and 8.9 miles of brick, in addition to which there are bridges with a total length of 11.5 miles.

The total cost of all Federal-aid roads completed, including 23.2 miles of stage construction, was $32,242,-064.54, of which the Federal share was $14,883,940.46. The disbursement of Federal funds to the State was $1,339,-252.44. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $17,811,678, leaves a balance of $2,812,013.26 unexpended funds to the credit of the State.

OREGON

The Federal-aid highway system includes 2,814 miles, of which 1,055.2 miles have been improved with Federal aid. Of the improved mileage, 93.6 miles were added during the year. At the close of the year 62.2 miles were under construction and 9.9 miles were approved.

The mileage improved with Federal aid consists of 145.3 miles of graded and drained earth roads, 728 miles of gravel, 25.6 miles of water-bound macadam, 0.8 mile of bituminous macadam, 52.9 miles of bituminous concrete, and 99.8 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of all Federal-aid roads completed, including 23 miles of stage construction, was $19,750,647.26, of which the Federal share was $10,141,-690.44. The disbursement of Federal funds to the State was $1,301,855.33. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $12,061,549, leaves a balance of $1,311,677.28 unexpended funds to the credit of the State.

PENNSYLVANIA

The Federal-aid highway system includes 4,602.1 miles, of which 1,639.5 miles have been improved with Federal aid. Of the improved mileage, 204.3 miles were added during the year. At the close of the year 217.9 miles were under construction and 64.2 miles were approved.

The mileage improved with Federal aid consists of 89.7 miles of graded and drained earth roads, 7.8 miles of bituminous macadam, 101.2 miles of bituminous concrete, 1,414.2 miles of Portland-cement concrete, and 26.4 miles of brick.

The total cost of all Federal-aid roads completed was $83,038,333.31, of which the Federal share was $27,819,175.23. The disbursement of Federal funds to the State was $3,180,313.25. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $34,674,516 leaves a balance of $6,-066,283.78 unexpended funds to the credit of the State.

RHODE ISLAND

The Federal-aid highway system includes 356.9 miles, of which 118.2 miles have been improved with Federal aid. Of the improved mileage, 23.9 miles were added during the year. At the close of the year 20.4 miles were under construction and 9.3 miles were approved.

The mileage improved with Federal aid consists of 1.8 miles of water-bound macadam, 17.4 miles of bituminous macadam, 47.3 miles of bituminous concrete, and 51.6 miles of Portland-cement concrete.

The total cost of all Federal-aid roads completed was $5,326,208.94, of which the Federal share was $2,030,654.06 The disbursement of Federal funds to the State was $466,586.24. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $3,-033,194 leaves a balance of $1,007,-778.70 unexpended funds to the credit of the State.

SOUTH CAROLINA

The Federal-aid highway system includes 3,230 miles, of which 1,639.2 miles have been improved with Federal aid. Of the improved mileage, 102.3 miles were added during the year. At the close of the year 165 miles were under construction and 22.9 miles were approved.

The mileage improved with Federal aid consists of 40.5 miles of graded and drained earth roads, 1,289.6 miles of sand-clay, 115.6 miles of gravel, 8.9 miles of water-bound macadam, 3 miles of bituminous macadam, 89 miles of bituminous concrete, 81.4 miles of Portland-cement concrete, and 0.2 mile of brick, in addition to which there are bridges with a total length of 10.9 miles.

The total cost of all Federal-aid roads completed, including 45.6 miles of stage construction, was $19,448,-510.98, of which the Federal share was $8,712,260.60. The disbursement of Federal funds to the State was $1,187,023.41. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $10,856,512, leaves a balance of $1,421,754.67 unexpended funds to the credit of the State.

SOUTH DAKOTA

The Federal-aid highway system includes 5,747 miles, of which 2,618.1 miles have been improved with Federal

aid. Of the improved mileage, 372.3 miles were added during the year. At the close of the year 508.4 miles were under construction and 131.5 miles were approved.

The mileage improved with Federal aid consists of 495.1 miles of graded and drained earth roads, 18.2 miles of sand-clay, 2,101.5 miles of gravel, and 1.2 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed, including 278.9 miles of stage construction, was $19,735,-884.45, of which the Federal share was $9,758,202.41. The disbursement of Federal funds to the State was $1,074,-687.39. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $12,386,854, leaves a balance of $1,942,005.03 unexpended funds to the credit of the State.

TENNESSEE

The Federal-aid highway system includes 3,252.8 miles, of which 975.4 miles have been improved with Federal aid. Of the improved mileage, 140.1 miles were added during the year. At the close of the year 119 miles were under construction.

The mileage improved with Federal aid consists of 149.4 miles of graded and drained earth roads, 117 miles of gravel, 52.2 miles of water-bound macadam, 416.2 miles of bituminous macadam, 27.7 miles of bituminous concrete, and 211.2 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of all Federal-aid roads completed, including 52 miles of stage construction, was $28,556,-694.76, of which the Federal share was $13,448,035.73. The disbursement of Federal funds to the State was $1,793,-804.55. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $16,895,357, leaves a balance of $3,024,467.64 unexpended funds to the credit of the State.

TEXAS

The Federal-aid highway system includes 11,404.7 miles, of which 5,658.2 miles have been improved with Federal aid. Of the improved mileage, 602.4 miles were added during the year. At the close of the year 343.3 miles were under construction and 54.7 miles were approved.

The mileage improved with Federal aid consists of 795 miles of graded and drained earth roads, 83.9 miles of sand-clay, 2,963 miles of gravel, 527 miles of water-bound macadam, 622.4 miles of bituminous macadam, 120.6 miles of bituminous concrete, 509.2 miles of Portland-cement concrete, and 29.2 miles of brick, in addition to which there are bridges with a total length of 8 miles.

The total cost of all Federal-aid roads completed, including 181.1 miles of stage construction, was $84,133,-673.64, of which the Federal share was $34,164,583.64. The disbursement of Federal funds to the State was $4,710,-228.42. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $45,103,703, leaves a balance of $8,982,385.50 unexpended funds to the credit of the State.

UTAH

The Federal-aid highway system includes 1,677.3 miles, of which 721.1 miles have been improved with Federal aid. Of the improved mileage, 98.5 miles were added during the year. At the close of the year 81.3 miles were under construction and 37.6 miles were approved.

The mileage improved with Federal aid consists of 94.3 miles of graded and drained earth roads, 41.7 miles of sand-clay, 472.1 miles of gravel, 9.3 miles of water-bound macadam, 0.7 mile of bituminous macadam, 9.9 miles of bituminous concrete, and 91.6 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 1.7 miles.

The total cost of all Federal-aid roads completed was $10,182,174.78, of which the Federal share was $6,550,122.70. The disbursement of Federal funds to the State was $830,082.69. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,665,685, leaves a balance of $1,806,-840.29 unexpended funds to the credit of the State.

VERMONT

The Federal-aid highway system includes 1,043 miles, of which 160.5 miles have been improved with Federal aid. Of the improved mileage, 25.3 miles were added during the year. At the close of the year 33.9 miles were under construction and 27.4 miles were approved.

The mileage improved with Federal aid consists of 99.8 miles of gravel, 3.5 miles of water-bound macadam, 30.1 miles of bituminous macadam, and 21.2 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 5.8 miles.

The total cost of all Federal-aid roads completed was $5,485,007.14, of which the Federal share was $2,545,061.70. The disbursement of Federal funds to the State was $625,423.73. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $3,634,132, leaves a balance of $847,317.80 unexpended funds to the credit of the State.

VIRGINIA

The Federal-aid highway system includes 3,233 miles, of which 1,182.8 miles have been improved with Federal aid. Of the improved mileage, 132.7 miles were added during the year. At the close of the year 95.5 miles were under construction and 19 miles were approved.

The mileage improved with Federal aid consists of 58.9 miles of graded and drained earth roads, 212.5 miles of sand-clay, 121.6 miles of gravel, 108.6 miles of water-bound macadam, 303.5 miles of bituminous macadam, 10.6 miles of bituminous concrete, and 364.7 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed was $27,331,674.40, of which the Federal share was $12,756,-334.06. The disbursement of Federal funds to the State was $1,868,896.29. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $14,944,228, leaves a balance of $1,674,225.98 unexpended funds to the credit of the State.

WASHINGTON

The Federal-aid highway system includes 2,927.5 miles, of which 722.2 miles have been improved with Federal aid. Of the improved mileage, 53.6 miles were added during the year. At the close of the year 57.1 miles were under construction and 10.1 miles were approved.

The mileage improved with Federal aid consists of 125.8 miles of graded and drained earth roads. 321.1 miles of gravel, and 273.2 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed, including 14.2 miles of stage construction, was $18,541,646.53, of which the Federal share was $8,411,-551.95. The disbursement of Federal funds to the State was $1,146,672.36. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $11,277,308, leaves a balance of $1,792,635.87 unexpended funds to the credit of the State.

WEST VIRGINIA

The Federal-aid highway system includes 2,000.6 miles, of which 474.2 miles have been improved with Federal aid. Of the improved mileage, 59.7 miles were added during the year. At the close of the year 183.4 miles were under construction and 26.9 miles were approved.

The mileage improved with Federal aid consists of 164.8 miles of graded and drained earth roads, 5.6 miles of sand-clay, 18.2 miles of gravel, 4.9 miles of water-bound macadam, 124.5 miles of bituminous macadam, 21.3 miles of bituminous concrete, 123.1 miles of Portland-cement concrete, and 11.4 miles of brick, in addition to which there are bridges with a total length of 0.5 mile.

The total cost of all Federal-aid roads completed, including 21.1 miles of stage construction, was $12,413,729.68, of which the Federal share was $5,373,-686.14. The disbursement of Federal funds to the State was $648,202.63. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $8,146,147, leaves a balance of $2,032,300.56 unexpended funds to the credit of the State.

WISCONSIN

The Federal-aid highway system includes 5,493.3 miles, of which 1,748.6 miles have been improved with Federal aid. Of the improved mileage, 129.5 miles were added during the year. At the close of the year 356.4 miles were under construction and 19.4 miles were approved.

The mileage improved with Federal aid consists of 206 miles of graded and drained earth roads, 115.5 miles of sand-clay, 920.8 miles of gravel, 2.7 miles of water-bound macadam, 13.8 miles of bituminous macadam, and 488.5 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed, including 88.7 miles of stage construction, was $28,360,-984.81, of which the Federal share was $12,068,823.90. The disbursement of Federal funds to the State was $2,357,-068.54. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $19,309,270, leaves a balance of $5,645,332.47 unexpended funds to the credit of the State.

WYOMING

The Federal-aid highway system includes 3,097 miles, of which 1,350.2 miles have been improved with Federal aid. Of the improved mileage, 125.1 miles were added during the year. At the close of the year 143.2 miles were under construction.

The mileage improved with Federal aid consists of 405.6 miles of graded and drained earth roads, 485.4 miles of sand-clay, 418 miles of gravel, 22.1 miles of bituminous concrete, and 14.8 miles of Portland-cement concrete, in addition to which there are bridges with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed, including 98.6 miles of stage construction, was $13,684,719.82, of which the Federal share was $7,816,311.16. The disbursement of Federal funds to the State was $696,804.42. This, added to the disbursements made during previous years and subtracted from the State's total apportionment of $9,500,643, leaves a balance of $1,568,534.67 unexpended funds to the credit of the State.

FEDERAL-AID STATISTICS

Complete statistics for the Federal-aid roads completed during the year and during the entire period since the passage of the Federal-aid road act of 1916, with reference to the mileage and type of roads constructed, their total cost, and Federal-aid allotments, etc., are given in Tables 9 to 19, inclusive.

TABLE 9.—*Total cost, Federal aid and mileage of Federal-aid roads, original and stage construction, completed during the fiscal year 1927, by States*

State	Total cost	Federal aid	Miles (original)	Miles (stage)
Alabama	$1,642,397.27	$794,616.21	78.3	4.6
Arizona	759,421.93	499,941.68	68.6	.4
Arkansas	2,380,855.89	1,132,085.21	168.9	
California	7,355,463.61	3,717,364.67	195.6	17.3
Colorado	2,958,510.73	1,468,361.60	166.6	
Connecticut	1,634,561.20	417,833.05	24.0	
Delaware	1,432,385.36	620,612.37	40.2	
Florida	2,402,385.61	1,133,408.48	65.9	
Georgia	8,318,990.63	3,992,430.39	394.3	63.3
Idaho	2,379,468.83	1,344,143.69	177.0	13.1
Illinois	2,259,678.01	1,080,098.80	76.3	2.0
Indiana	4,899,996.16	2,247,501.37	154.3	11.6
Iowa	6,495,281.14	3,074,642.42	415.6	74.3
Kansas	5,610,039.92	2,425,016.73	361.1	.1
Kentucky	3,191,460.09	1,350,461.54	110.6	14.6
Louisiana	2,624,942.63	1,229,355.95	144.7	
Maine	1,916,182.04	715,412.65	59.2	
Maryland	999,532.55	471,467.05	58.5	
Massachusetts	3,743,211.50	1,060,946.19	55.0	
Michigan	7,520,266.98	3,153,877.40	165.7	25.7
Minnesota	7,248,884.52	3,133,529.11	394.3	114.6
Mississippi	3,319,730.75	1,657,054.77	217.8	
Missouri	9,486,643.42	4,152,613.71	281.9	29.6
Montana	1,023,396.10	740,036.65	90.3	62.6
Nebraska	5,929,773.22	2,911,147.90	629.9	238.6
Nevada	1,734,244.90	1,473,599.53	230.6	11.0
New Hampshire	705,801.62	317,313.41	23.9	
New Jersey	6,676,462.88	2,561,536.50	37.2	
New Mexico	792,954.91	550,442.63	69.8	
New York	11,175,905.65	3,799,425.96	248.0	
North Carolina	5,336,143.65	2,127,764.59	145.9	37.5
North Dakota	3,203,927.76	1,622,360.21	576.0	362.9
Ohio	4,431,814.99	1,753,398.02	128.1	13.4
Oklahoma	3,326,117.61	1,399,083.88	183.0	10.1
Oregon	2,137,788.85	1,196,486.51	93.6	
Pennsylvania	8,226,260.64	2,712,208.40	204.3	
Rhode Island	1,006,002.25	357,750.00	23.9	
South Carolina	2,259,842.16	932,884.49	102.3	15.4
South Dakota	1,545,292.60	809,569.76	272.3	154.4
Tennessee	5,415,909.15	2,452,111.40	140.1	19.1
Texas	12,730,327.00	5,703,444.94	602.4	39.8
Utah	1,127,941.98	859,078.73	98.5	
Vermont	1,211,037.88	516,577.19	25.3	
Virginia	3,921,183.08	1,783,765.41	132.7	
Washington	1,463,134.90	628,642.49	53.6	
West Virginia	2,155,588.48	882,257.48	59.7	
Wisconsin	3,007,950.61	1,430,427.17	129.5	7.8
Wyoming	1,301,331.74	838,829.53	125.1	32.8
Hawaii	343,664.15	97,440.00	6.5	
Total	182,770,089.53	81,330,357.82	8,306.9	1,376.6

TABLE 10.—*Total cost, Federal aid and mileage of Federal-aid roads completed to June 30, 1927, by States*

State	Total cost	Federal aid	Miles [1]
Alabama	$22,394,983.26	$10,678,040.69	1,494.0
Arizona	12,288,747.00	6,750,136.37	835.7
Arkansas	22,638,788.64	9,675,983.97	1,587.4
California	37,590,843.42	18,275,993.48	1,365.3
Colorado	18,184,354.89	9,269,990.10	963.6
Connecticut	7,612,390.21	2,691,696.71	151.1
Delaware	6,350,437.65	2,402,277.97	164.5
Florida	10,391,903.41	5,011,696.35	315.6
Georgia	36,023,188.89	17,101,498.97	2,369.8
Idaho	14,160,210.06	7,669,247.11	950.7
Illinois	48,898,354.53	22,958,520.84	1,543.4
Indiana	27,496,654.62	13,147,848.20	841.5
Iowa	36,686,963.96	15,507,575.57	2,592.6
Kansas	40,056,652.74	15,781,141.51	1,624.7
Kentucky	24,510,594.46	10,092,978.19	898.0
Louisiana	16,906,801.67	7,588,692.38	1,214.5
Maine	10,663,734.80	4,907,920.04	362.8
Maryland	11,924,475.65	5,584,458.27	481.8
Massachusetts	22,960,850.63	7,959,329.39	440.7
Michigan	34,875,126.43	15,628,180.61	1,161.5
Minnesota	45,099,648.47	19,046,145.67	3,643.5
Mississippi	19,036,438.71	9,356,898.57	1,376.7
Missouri	47,057,985.96	21,442,541.23	2,077.6
Montana	12,937,675.16	7,347,567.20	1,161.8
Nebraska	20,308,791.23	9,779,936.76	2,651.1
Nevada	11,049,750.51	8,133,489.64	940.7
New Hampshire	5,966,371.13	2,827,664.73	268.5
New Jersey	24,357,307.14	7,939,988.87	345.1
New Mexico	13,993,014.03	8,401,600.54	1,560.3
New York	56,632,985.44	22,425,513.15	1,479.8
North Carolina	36,025,574.41	14,869,283.31	1,489.0
North Dakota	16,716,504.05	8,225,349.31	2,851.7
Ohio	53,799,465.23	19,827,851.84	1,550.7
Oklahoma	32,242,064.54	14,883,940.46	1,384.5
Oregon	19,750,647.26	10,141,690.44	1,055.2
Pennsylvania	83,038,333.31	27,819,175.23	1,639.5
Rhode Island	5,326,208.94	2,030,654.06	118.2
South Carolina	19,448,510.98	8,712,260.60	1,639.2
South Dakota	19,735,884.45	9,758,202.41	2,618.1
Tennessee	28,556,694.76	13,448,035.73	975.4
Texas	84,133,673.64	34,164,583.64	5,658.2
Utah	10,182,174.78	6,550,122.70	721.1
Vermont	5,485,007.14	2,545,061.70	160.5
Virginia	27,331,674.40	12,756,334.06	1,182.8
Washington	18,541,646.53	8,411,551.95	722.2
West Virginia	12,413,729.68	5,373,686.14	474.2
Wisconsin	28,360,984.81	12,068,823.90	1,748.6
Wyoming	13,684,719.82	7,816,311.16	1,350.2
Hawaii	343,664.15	97,440.00	6.5
Total	1,234,173,187.58	544,884,911.72	64,209.7

[1] Mileage is of original improvement only.

TABLE 11.—*Total program as of June 30, 1927, of projects which have been approved for construction, completed, and under construction*

State	Total cost	Federal aid	Miles [1]
Alabama	$26,892,327.66	$12,874,711.93	1,795.8
Arizona	13,573,562.27	7,756,017.18	882.6
Arkansas	26,169,062.71	11,195,836.69	1,791.5
California	42,652,152.33	20,449,769.87	1,462.2
Colorado	21,824,043.72	11,028,895.64	1,108.0
Connecticut	12,958,034.68	4,212,119.89	214.2
Delaware	7,397,224.63	2,791,815.99	203.4
Florida	17,523,370.46	7,923,638.69	465.6
Georgia	40,239,287.71	19,190,898.09	2,507.6
Idaho	16,092,498.85	8,855,522.64	1,043.9
Illinois	64,033,039.12	30,283,916.57	2,073.6
Indiana	41,337,877.45	19,752,019.30	1,278.2
Iowa	50,125,904.34	21,380,719.11	3,093.1
Kansas	53,458,554.93	21,056,443.28	2,346.8
Kentucky	33,447,506.06	14,346,680.12	1,334.2
Louisiana	21,139,869.20	9,338,158.64	1,320.5
Maine	13,539,961.13	5,895,203.10	438.0
Maryland	13,992,821.63	6,472,923.91	578.3
Massachusetts	26,830,477.64	9,001,408.84	505.6
Michigan	45,044,065.43	20,321,953.34	1,475.8
Minnesota	52,696,131.59	21,162,044.57	4,032.9
Mississippi	25,857,554.89	12,658,131.29	1,743.0
Missouri	53,105,121.82	24,202,844.57	2,280.0
Montana	17,727,900.08	10,589,158.05	1,587.3
Nebraska	31,151,224.65	15,147,880.43	3,718.3
Nevada	11,941,462.47	8,903,528.35	1,036.3
New Hampshire	7,247,059.04	3,392,317.74	304.4
New Jersey	30,186,703.57	9,234,383.04	433.5
New Mexico	16,675,155.12	10,524,013.28	1,738.8
New York	102,623,971.44	33,579,477.10	2,174.7
North Carolina	39,421,253.17	16,464,798.83	1,584.5
North Dakota	22,962,132.22	11,503,422.80	3,775.3
Ohio	65,061,641.92	24,142,358.08	1,870.1
Oklahoma	35,443,999.66	16,317,269.06	1,590.8
Oregon	22,081,219.74	11,343,219.92	1,127.3
Pennsylvania	97,156,742.34	32,454,985.56	1,921.6
Rhode Island	7,098,907.42	2,489,872.80	147.9
South Carolina	24,037,642.52	10,455,890.20	1,827.1
South Dakota	23,540,214.78	11,814,303.22	3,258.0
Tennessee	33,075,863.23	15,166,144.62	1,094.4
Texas	94,658,795.27	38,917,998.81	6,056.2
Utah	12,053,483.28	7,954,338.21	840.0
Vermont	8,381,603.22	3,591,524.14	221.8
Virginia	32,600,170.83	14,869,554.36	1,297.3
Washington	22,112,456.42	10,062,151.95	789.4
West Virginia	18,280,061.74	7,833,676.68	684.5
Wisconsin	38,423,174.53	16,748,937.70	2,124.4
Wyoming	15,055,365.96	8,696,364.00	1,493.4
Hawaii	2,129,988.04	659,802.64	36.2
Total	1,551,058,642.91	675,059,044.82	76,708.3

[1] Mileage is of original improvement only.

TABLE 12.—*Mileage of Federal-aid roads completed during the fiscal year 1927 by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land-cement con-crete	Brick	Bridges	Total
Alabama	44.0	0.4	12.3			6.7	14.4		0.4	78.3
Arizona	27.5	9.2	27.7			4.0			.3	68.6
Arkansas			140.3	.2	14.8	7.9	4.0		1.6	168.9
California	37.2		68.1	.6	7.3	18.6	61.4		2.2	195.6
Colorado	59.2	28.8	54.4				22.6		1.7	166.6
Connecticut			.2				23.6		.3	24.0
Delaware				5.0			35.2			40.2
Florida [1]	9.8		21.8	−6.9		18.5	22.2		.4	65.9
Georgia	90.3	150.3	77.7	24.7	17.4		31.9		2.2	394.3
Idaho	63.2	6.0	86.7			17.3	2.9		.9	177.0
Illinois							76.3			76.3
Indiana	3.0			45.1			104.8		1.4	154.3
Iowa	283.6		76.5				54.4		1.0	415.6
Kansas	249.5	23.4	17.3		13.1		39.7	11.4	6.7	361.1
Kentucky	85.6		2.5		13.6		8.5		.4	110.6
Louisiana	21.8		115.1				7.1		.7	144.7
Maine			29.3		17.9		12.1			59.2
Maryland					45.8	4.7	8.1			58.5
Massachusetts				.2	28.5		24.4		1.8	55.0
Michigan	.4		23.6				141.3		.4	165.9
Minnesota	143.0		131.3			4.8	115.2			394.3
Mississippi	77.5	.9	103.0			.3	35.9		.1	217.8
Missouri	46.1		19.8				201.8	12.5	1.7	281.9
Montana	4.1		85.8						.1	90.3
Nebraska	103.6	286.7	229.7			.7	7.4		2.1	629.9
Nevada	3.5		220.9		5.0				1.2	230.6
New Hampshire			2.7	7.3	8.6	2.6	2.6		.1	23.9
New Jersey	4.6						31.0		1.6	37.2
New Mexico [1]	17.6		58.1				−6.3		.3	69.8
New York	2.4		14.2		24.4	6.7	200.3			248.0
North Carolina	9.0					21.0	115.8		.2	145.9
North Dakota	407.8	23.5	137.6	1.0		.6	1.6		3.9	576.0
Ohio	7.6			20.7	16.9	5.7	60.7	15.9	.6	128.1
Oklahoma	126.5		9.9			13.9	30.5		2.1	183.0
Oregon	15.9		68.9				8.4		.5	93.6
Pennsylvania	56.9						147.3			204.3
Rhode Island [1]				−.1	.9	9.0	14.1			23.9
South Carolina	6.4	71.6	1.0	2.9		7.4	9.9		3.1	102.3
South Dakota	168.3		103.7						.1	272.3
Tennessee	60.8				14.5	5.8	58.9		.1	140.1
Texas [1]	211.7		104.6	36.4	149.1	−1.1	100.9		1.1	602.4
Utah			98.4						.1	98.5
Vermont			12.8		5.2		5.1		2.2	25.3
Virginia	7.1	10.3	7.7		54.6		52.1		.8	132.7
Washington	17.0		9.7				26.8		.1	53.6
West Virginia	7.4				14.5	5.0	32.8			59.7
Wisconsin			69.5		4.2		54.7		1.3	129.5
Wyoming	57.2	1.0	66.7						.1	125.1
Hawaii					6.5					6.5
Total	2,537.1	612.1	2,309.5	137.1	462.7	159.9	2,002.7	39.8	45.9	8,306.9

[1] Negative figures caused by revision of records when final vouchers were paid on projects the type of which was changed after ratification of project agreement.

TABLE 13.—*Mileage of Federal-aid roads completed to June 30, 1927, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land-cement con-crete	Brick	Bridges	Total
Alabama	72.3	413.2	780.9	11.6	53.2	87.5	71.9	------	3.3	1,494.0
Arizona	124.2	131.4	428.2	14.2	--------	26.6	108.5	------	2.6	835.7
Arkansas	--------	3.0	1,059.5	48.4	98.9	256.3	118.2	------	3.3	1,587.4
California	314.0	--------	348.5	18.6	63.1	85.9	530.0	------	4.9	1,365.3
Colorado	231.7	105.7	409.0	--------	--------	4.0	207.3	------	6.0	963.6
Connecticut	--------	--------	.2	8.7	27.1	--------	114.9	------	.3	151.1
Delaware	--------	--------	--------	5.0	--------	--------	153.1	6.2	.2	164.5
Florida	9.8	21.1	34.8	18.5	72.7	41.8	103.9	10.1	3.0	315.6
Georgia	166.0	1,257.7	423.3	73.1	123.1	25.9	275.2	.5	25.2	2,369.8
Idaho	228.7	22.7	591.4	4.3	4.9	61.0	35.9	------	2.0	950.7
Illinois	110.4	--------	--------	--------	3.3	8.1	1,394.4	25.8	1.4	1,543.4
Indiana	17.0	--------	33.5	56.7	17.0	12.0	702.3	------	2.9	841.5
Iowa	1,469.0	--------	586.4	--------	--------	--------	514.0	22.0	1.2	2,592.6
Kansas	562.1	135.7	198.0	4.5	97.7	3.4	479.3	134.4	9.2	1,624.7
Kentucky	411.2	--------	160.6	41.4	153.4	--------	126.9	3.9	.6	898.0
Louisiana	25.2	--------	1,152.1	3.2	9.5	10.4	10.7	------	3.5	1,214.5
Maine	--------	--------	156.0	--------	155.3	--------	51.4	------	.2	362.8
Maryland	4.7	--------	31.5	.1	152.6	17.0	276.0	------	--------	481.8
Massachusetts	--------	--------	--------	3.5	227.7	36.8	168.2	------	4.3	440.7
Michigan	.5	--------	329.9	18.9	10.4	73.5	727.7	.4	.4	1,161.5
Minnesota	490.0	6.2	2,630.1	--------	--------	32.6	483.9	------	.6	3,643.5
Mississippi	213.9	21.5	976.6	11.1	1.0	9.5	133.1	9.2	.6	1,376.7
Missouri	340.0	--------	867.4	13.4	50.9	17.8	757.7	20.9	9.1	2,077.6
Montana	213.1	5.6	883.7	16.0	6.9	2.8	31.3	------	2.5	1,161.8
Nebraska	922.9	764.6	873.7	--------	--------	11.0	55.0	18.7	5.3	2,651.1
Nevada	40.6	26.4	792.9	10.2	20.6	2.0	44.9	------	3.3	940.7
New Hampshire	--------	--------	99.1	53.8	72.5	32.6	7.7	------	2.6	268.5
New Jersey	6.2	.8	3.8	--------	--------	21.9	310.1	------	2.3	345.1
New Mexico	243.4	5.1	1,239.4	--------	--------	.7	70.1	------	1.6	1,560.3
New York	2.4	--------	22.8	--------	345.1	11.5	1,096.0	.7	1.5	1,479.8
North Carolina	89.6	521.1	70.9	19.6	37.9	249.4	498.3	------	2.1	1,489.0
North Dakota	1,458.6	25.1	1,354.3	1.0	--------	1.9	4.7	------	6.0	2,851.7
Ohio	41.2	--------	6.7	103.3	320.1	93.8	539.9	444.9	.7	1,550.7
Oklahoma	219.8	2.3	605.6	6.3	8.4	78.4	443.0	8.9	11.5	1,384.5
Oregon	145.3	--------	728.0	25.6	.8	52.9	99.8	------	2.8	1,055.2
Pennsylvania	89.7	--------	--------	--------	7.8	101.2	1,414.2	26.4	--------	1,639.5
Rhode Island	--------	--------	--------	1.8	17.4	47.3	51.6	------	--------	118.2
South Carolina	40.5	1,289.6	115.6	8.9	3.0	89.0	81.4	.2	10.9	1,639.2
South Dakota	495.1	18.2	2,101.5	--------	--------	--------	1.2	------	2.1	2,618.1
Tennessee	149.4	--------	117.0	52.2	416.2	27.7	211.2	------	1.6	975.4
Texas	795.0	83.9	2,963.0	527.0	622.4	120.6	509.2	29.2	8.0	5,658.2
Utah	94.3	41.7	472.1	9.3	.7	9.9	91.6	------	1.7	721.1
Vermont	--------	--------	99.8	3.5	30.1	--------	21.2	------	5.8	160.5
Virginia	58.9	212.5	121.6	108.6	303.5	10.6	364.7	------	2.4	1,182.8
Washington	125.8	--------	321.1	--------	--------	--------	273.2	------	2.1	722.2
West Virginia	164.8	5.6	18.2	4.9	124.5	21.3	123.1	11.4	.5	474.2
Wisconsin	206.0	115.5	920.8	2.7	13.8	--------	488.5	------	1.4	1,748.6
Wyoming	405.6	485.4	418.0	--------	--------	22.1	14.8	------	4.1	1,350.2
Hawaii	--------	--------	--------	--------	6.5	--------	--------	------	--------	6.5
Total	10,798.9	5,721.7	25,547.5	1,309.9	3,680.0	1,818.9	14,391.2	773.8	167.6	64,209.7

TABLE 14.—*Mileage of Federal-aid roads under construction on June 30, 1927, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land-cement con-crete	Brick	Bridges	Total
Alabama	102.1	87.6	87.0		21.1		1.7		0.5	299.9
Arizona		11.6	14.1				.4		1.7	27.8
Arkansas	44.1		120.7		17.6		1.2		1.1	184.7
California	30.4		21.2	9.8		6.4	23.8		.8	92.4
Colorado	33.1	11.2	57.7				38.6		1.0	141.5
Connecticut				8.2			38.4		3.5	50.1
Delaware							27.6		.3	27.9
Florida	56.5			16.2	23.4	13.9	11.5		4.3	125.8
Georgia	69.7	19.8	9.7	6.8	7.5		23.5		.6	137.5
Idaho	8.8		63.4			7.8	3.4		.6	83.9
Illinois	44.4						292.4	6.2	.4	343.4
Indiana	10.7						345.6	11.0	.6	367.9
Iowa	160.7		67.1				228.5		.3	456.6
Kansas	337.3	31.3	28.1		27.8		104.0	22.5	4.1	555.1
Kentucky	256.8		30.9		66.3		39.0		.4	393.4
Louisiana	22.9		43.4			23.7	12.9		2.2	105.1
Maine			36.1		1.9		30.3		1.2	69.6
Maryland					11.5		18.4			29.9
Massachusetts			0.5		34.1	9.8	17.9		.3	62.6
Michigan	43.9		42.7				199.5		1.9	288.0
Minnesota	354.4		6.2				9.4		.1	370.0
Mississippi	144.8		120.1				33.4	.5	2.2	301.1
Missouri	56.1		3.4				74.4			134.0
Montana	4.3		114.0	.8					.5	119.6
Nebraska	224.1	559.8	101.1			.2	14.9		.4	900.6
Nevada			95.6							95.6
New Hampshire				11.7	8.9		4.2		2.2	27.1
New Jersey	2.8						79.7			82.5
New Mexico	70.7		98.2				8.6		1.0	178.5
New York	52.0		28.0		13.3		445.5		.4	539.3
North Carolina							58.1		.6	58.7
North Dakota	571.2	2.5	28.5						.6	602.8
Ohio	44.0			28.4	74.6		131.8	18.1	1.8	298.6
Oklahoma	106.2						27.2		1.3	134.8
Oregon	57.0		4.8						.3	62.2
Pennsylvania	44.1				22.9		150.7		.1	217.9
Rhode Island					15.1		5.3			20.4
South Carolina	8.8	105.8	18.5			1.0	25.3		5.7	165.0
South Dakota	379.9		112.3				15.7		.5	508.4
Tennessee	65.3		6.8		12.6	5.6	27.3		1.4	119.0
Texas	133.3		50.7	5.9	102.9		48.8		1.7	343.3
Utah			80.5						.8	81.3
Vermont			1.1		15.2		17.2		.4	33.9
Virginia					11.5		82.8		1.2	95.5
Washington	27.7		27.5						1.9	57.1
West Virginia	112.5		5.4		25.1	19.3	19.9		1.2	183.4
Wisconsin	8.4	8.2	192.9				145.3		1.7	356.4
Wyoming	122.4		15.3				5.2		.4	143.2
Hawaii					13.8		15.9			29.7
Total	3,811.4	837.8	1,733.5	87.8	527.1	87.7	2,905.2	58.3	54.2	10,103.0

TABLE 15.—*Mileage of Federal-aid roads approved for construction on June 30, 1927*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land-cement con-crete	Brick	Bridges	Total
Alabama		1.8							0.1	1.9
Arizona		19.0							.1	19.1
Arkansas	15.6						1.4		2.4	19.4
California						4.5				4.5
Colorado			2.9							2.9
Connecticut							12.7		.3	13.0
Delaware			5.7		5.3					11.0
Florida					23.8				.4	24.2
Georgia							.3			.3
Idaho	2.2		6.7						.4	9.3
Illinois	37.5						149.2		.2	187.0
Indiana							68.8			68.8
Iowa	3.4		1.2				39.5			44.1
Kansas	77.4	51.2	27.4				10.5		.5	167.0
Kentucky	38.6				4.0				.2	42.8
Louisiana									.9	.9
Maine			5.6							5.6
Maryland					38.9		27.7			66.6
Massachusetts							2.3			2.3
Michigan			3.2				22.9		.2	26.3
Minnesota	19.4									19.4
Mississippi	39.0		24.2				2.0			65.2
Missouri	28.7						39.5		.2	68.4
Montana	28.5		255.5	20.6					1.3	305.9
Nebraska	40.9	119.2	2.5				2.8		1.2	166.6
New Hampshire				.9	6.1		1.8			8.8
New Jersey							5.9			5.9
New York			10.9		13.2		131.5			155.6
North Carolina							36.8			36.8
North Dakota	306.3		14.4						.1	320.8
Ohio	3.1			2.3			15.0	0.2	.2	20.8
Oklahoma	65.3						6.1		.1	71.5
Oregon	9.9									9.9
Pennsylvania	3.4						59.9		.9	64.2
Rhode Island					3.5		5.8			9.3
South Carolina	8.0					11.5	3.4			22.9
South Dakota	115.6		15.7						.2	131.5
Texas	34.9		7.2	9.1	.9		2.5			54.7
Utah			37.6						.1	37.6
Vermont			5.7		4.3		17.3		.2	27.4
Virginia			.2				18.7		.1	19.0
Washington	6.5						3.6			10.1
West Virginia	5.7		5.9				15.3			26.9
Wisconsin			9.7				9.7			19.4
Total	889.9	191.2	442.2	32.9	100.0	16.0	712.9	.2	10.3	2,395.6

TABLE 16.—*Mileage of stage construction completed during fiscal year 1927, by types of construction*

State	Graded and drained	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland-cement concrete	Total
Alabama						4.6	4.6
Arizona		0.4					.4
California						17.3	17.3
Georgia			8.8	9.8	10.0	34.7	63.3
Idaho				4.9	8.0	.2	13.1
Illinois						2.0	2.0
Indiana			11.6				11.6
Iowa		54.4				19.8	74.3
Kansas						.1	.1
Kentucky						14.6	14.6
Michigan						25.7	25.7
Minnesota		81.4				33.2	114.6
Missouri		2.7				26.9	29.6
Montana		62.6					62.6
Nebraska	21.0	206.1			.1	11.5	238.6
Nevada		11.0					11.0
North Carolina					8.6	28.9	37.5
North Dakota		362.8				.1	362.9
Ohio		6.7				6.7	13.4
Oklahoma						10.1	10.1
South Carolina					12.0	3.4	15.4
South Dakota		154.4					154.4
Tennessee						19.1	19.1
Texas		6.5		10.9		22.5	39.8
Wisconsin		7.8					7.8
Wyoming		32.8					32.8
Total	21.0	989.6	20.3	25.6	38.7	281.4	1,376.6

TABLE 17.—*Mileage of projects on which stage construction was in progress on June 30, 1927*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland-cement concrete	Brick	Total
Alabama							1.9		1.9
Colorado						9.1			9.1
Delaware							1.8		1.8
Georgia							40.0		40.0
Idaho						15.5			15.5
Iowa			85.1				81.3		166.4
Kansas		3.5					4.1		7.6
Kentucky					4.1				4.1
Minnesota			3.9				111.8		115.7
Mississippi							14.8		14.8
Missouri	9.9		3.0				16.4		29.3
Montana			1.6	4.1					5.7
Nebraska		307.3	3.5				33.4		344.1
North Dakota			118.5						118.5
Ohio							3.4	.8	4.2
Oklahoma							12.2		12.2
Oregon			32.6						32.6
South Carolina							13.0		13.0
South Dakota			38.2						38.2
Tennessee							27.5		27.5
Texas				14.2	103.0	4.4	18.2		139.7
West Virginia					4.0				4.0
Wisconsin			4.5				30.7		35.2
Wyoming			32.2						32.2
Total	9.9	310.8	323.1	18.3	111.1	29.0	410.3	.8	1,213.3

TABLE 18.—*Status of Federal-aid highway system, June 30, 1927*

State	Mileage of Federal-aid system approved to June 30, 1927	Federal-aid mileage completed during fiscal year	Federal-aid mileage completed to June 30, 1927
Alabama	3,884.0	78.3	1,494.0
Arizona	1,498.0	68.6	835.7
Arkansas	5,021.1	168.9	1,587.4
California	4,771.5	195.6	1,365.3
Colorado	3,332.0	166.6	963.6
Connecticut	835.4	24.0	151.1
Delaware	415.8	40.2	164.5
Florida	1,926.0	65.9	315.6
Georgia	5,558.4	394.3	2,369.8
Idaho	2,770.0	177.0	950.7
Illinois	6,616.8	76.3	1,543.4
Indiana	4,701.5	154.3	841.5
Iowa	7,212.0	415.6	2,592.6
Kansas	7,892.0	361.1	1,624.7
Kentucky	3,702.5	110.6	898.0
Louisiana	2,722.8	144.7	1,214.5
Maine	1,393.5	59.2	362.8
Maryland	1,503.7	58.5	481.8
Massachusetts	1,308.0	55.0	440.7
Michigan	5,235.0	165.9	1,161.5
Minnesota	6,849.6	394.3	3,643.5
Mississippi	3,604.0	217.8	1,376.7
Missouri	7,530.0	281.9	2,077.6
Montana	4,665.0	90.3	1,161.8
Nebraska	5,569.1	629.9	2,651.1
Nevada	1,398.0	230.6	940.7
New Hampshire	980.9	23.9	268.5
New Jersey	1,198.3	37.2	345.1
New Mexico	3,298.0	69.8	1,560.3
New York	5,018.0	248.0	1,479.8
North Carolina	3,860.8	145.9	1,489.0
North Dakota	7,194.0	576.0	2,851.7
Ohio	5,899.3	128.1	1,550.7
Oklahoma	5,528.0	183.0	1,384.5
Oregon	2,814.0	93.6	1,055.2
Pennsylvania	4,602.1	204.3	1,639.5
Rhode Island	356.9	23.9	118.2
South Carolina	3,230.0	102.3	1,639.2
South Dakota	5,747.0	272.3	2,618.1
Tennessee	3,252.8	140.1	975.4
Texas	11,404.7	602.4	5,658.2
Utah	1,677.3	98.5	721.1
Vermont	1,043.0	25.3	160.5
Virginia	3,233.0	132.7	1,182.8
Washington	2,927.5	53.6	722.2
West Virginia	2,000.6	59.7	474.2
Wisconsin	5,493.3	129.5	1,748.6
Wyoming	3,097.0	125.1	1,350.2
Hawaii	----------	6.5	6.5
Total	185,772.2	8,306.9	64,209.7

TABLE 19.—*Federal-aid apportionments to States, expenditures, and balances, as of June 30, 1927*

States	Apportionments	Expenditures	Balances unexpended
Alabama	$15,896,675.00	$11,125,402.51	$4,771,272.49
Arizona	10,674,243.00	6,980,384.61	3,693,858.39
Arkansas	12,883,700.00	10,089,256.29	2,794,443.71
California	24,556,252.00	19,099,020.27	5,457,231.73
Colorado	13,702,332.00	9,418,994.91	4,283,337.09
Connecticut	4,806,366.00	2,966,704.26	1,839,661.74
Delaware	2,839,683.00	2,367,415.41	472,267.59
Florida	8,984,405.00	6,283,048.37	2,701,356.63
Georgia	20,411,162.00	17,975,400.90	2,435,761.10
Idaho	9,494,820.00	7,924,889.57	1,569,930.43
Illinois	32,986,627.00	24,974,208.95	8,012,418.05
Indiana	20,131,127.00	15,560,764.82	4,570,362.18
Iowa	21,530,562.00	16,647,810.85	4,882,751.15
Kansas	21,532,943.00	17,402,790.48	4,130,152.52
Kentucky	14,630,756.00	11,330,190.92	3,300,565.08
Louisiana	10,285,716.00	8,158,528.87	2,127,187.13
Maine	7,145,622.00	5,385,074.63	1,760,547.37
Maryland	6,560,176.00	5,796,203.88	763,972.12
Massachusetts	11,197,826.00	7,593,592.97	3,604,233.03
Michigan	22,557,056.00	17,355,453.04	5,201,602.96
Minnesota	21,712,521.00	19,523,215.55	2,189,305.45
Mississippi	13,435,897.00	10,709,299.33	2,726,597.67
Missouri	25,191,611.00	20,896,412.65	4,295,198.35
Montana	14,976,384.00	7,777,595.32	7,198,788.68
Nebraska	16,220,373.00	11,234,189.87	4,986,183.13
Nevada	9,743,725.00	8,577,014.05	1,166,710.95
New Hampshire	3,535,117.00	2,906,382.08	628,734.92
New Jersey	9,402,031.00	7,495,364.48	1,906,666.52
New Mexico	12,159,149.00	8,985,251.20	3,173,897.80
New York	37,680,412.00	25,044,440.67	12,635,971.33
North Carolina	17,430,562.00	15,316,377.52	2,114,184.48
North Dakota	11,943,610.00	9,330,969.92	2,612,640.08
Ohio	28,494,005.00	21,753,059.40	6,740,945.60
Oklahoma	17,811,678.00	14,999,664.74	2,812,013.26
Oregon	12,061,549.00	10,749,871.72	1,311,677.28
Pennsylvania	34,674,516.00	28,608,232.22	6,066,283.78
Rhode Island	3,033,194.00	2,025,415.30	1,007,778.70
South Carolina	10,856,512.00	9,434,757.33	1,421,754.67
South Dakota	12,386,854.00	10,444,848.97	1,942,005.03
Tennessee	16,895,357.00	13,870,889.36	3,024,467.64
Texas	45,103,703.00	36,121,317.50	8,982,385.50
Utah	8,665,685.00	6,858,844.71	1,806,840.29
Vermont	3,634,132.00	2,786,814.20	847,317.80
Virginia	14,944,228.00	13,270,002.02	1,674,225.98
Washington	11,277,308.00	9,484,672.13	1,792,635.87
West Virginia	8,146,147.00	6,113,846.44	2,032,300.56
Wisconsin	19,309,270.00	13,663,937.53	5,645,332.47
Wyoming	9,500,643.00	7,932,108.33	1,568,534.67
Hawaii	1,465,778.00	321,617.71	1,144,160.29
Total	744,500,000.00	580,671,548.76	163,828,451.24

NATIONAL-FOREST ROAD CONSTRUCTION

The systems of forest roads in the several States have been increased by new designations during the year and now include 13,842 miles, of which 11,522 miles are in the 11 States of the Mountain and Pacific groups and the Territory of Alaska. As previously reported, all appropriations for forest-road construction are being expended upon these systems.

As shown by Table 20, the mileage of class 1 highways, upon which it is planned to expend until they are completed approximately 70 per cent of each annual appropriation is now 1,079 miles, of which 833 miles are in the Western States. These are the more important highways which are necessary sections or extensions of the Federal-aid system wholly within the forest areas. The class 2 highways, which also extend the Federal-aid system, are increased by the recent additions to a total mileage of 7,060, of which 6,687 miles are in the West, and the class 3 highways—those that serve principally the communities within the forests—now aggregate 5,703 miles, of which 4,002 miles are in the 11 Western States and Alaska.

TABLE 20.—*Classified mileage of forest highway system in several States*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Western:	*Miles*	*Miles*	*Miles*	*Miles*
Alaska			373.6	373.6
Arizona	174.0	499.0	248.0	921.0
California	322.9	995.6	757.0	2,075.5
Colorado		1,243.0	527.0	1,770.0
Idaho		738.1	351.1	1,089.2
Montana	145.0	660.0	377.0	1,182.0
Nevada		366.0	94.0	460.0
New Mexico [1]	115.0	211.0	199.0	525.0
Oregon [1]	58.0	872.4	445.0	1,375.4
Utah		457.9	299.0	756.9
Washington	18.4	263.7	181.9	464.0
Wyoming		380.0	149.0	529.0
Total	833.3	6,686.7	4,001.6	11,521.6
Eastern:				
Alabama			46.5	46.5
Arkansas	131.0	51.0	20.0	202.0
Florida	3.0	13.0	106.0	122.0
Georgia	18.0		115.0	133.0
Kentucky		6.0	6.0	12.0
Maine			11.0	11.0
Michigan			55.0	55.0
Minnesota		38.5	142.0	180.5
Nebraska			25.0	25.0
New Hampshire	18.3	15.5	62.5	96.3
New Jersey		3.0	5.5	8.5
North Carolina	49.0		199.0	248.0
Oklahoma			33.0	33.0
Pennsylvania	24.5		166.0	190.5
Porto Rico				
South Carolina		6.0	40.0	46.0
South Dakota	2.0	153.0	59.0	214.0
Tennessee		55.0	188.0	243.0
Virginia		28.0	273.0	301.0
West Virginia		4.0	149.0	153.0
Total	245.8	373.0	1,701.5	2,320.3
Grand total	1,079.1	7,059.7	5,703.1	13,841.9

[1] System designated by Bureau of Public Roads not yet approved by the Secretary of Agriculture.

As shown by Table 21, 452.85 miles of forest highways of all classes were completed during the year. Of this total, 378.9 miles were in the 11 Western States and Alaska and the remaining 73.95 miles were in the forest areas of 7 Eastern States.

The total mileage completed to date, including the results of the last year's work, is 3,498.45 miles, of which 3,182.94 miles is in the West and 315.51 miles in the East.

Outstanding in the work of the year was the completion of the Durango-Silverton Road in Colorado. This famous project in the San Juan National Forest has been under construction since 1918. Lying on the west slope of the Continental Divide, it serves as the north entrance to the San Juan Basin and one of the best approaches to Mesa Verde National Park. On account of the altitude, it is closed by snow for all but three and a half months in the summer. The section built by the Government is 33.14 miles in length, and with the widening which was effected after completion of the original construction the cost has been $560,550.

TABLE 21.—*Mileage of completed forest highway projects by States*

State	Mileage of forest highway projects completed	
	During 1927	Total to June 30, 1927
Western:	*Miles*	*Miles*
Alaska	5.21	151.62
Arizona	20.47	237.12
California	49.60	252.16
Colorado	54.56	265.96
Idaho	55.96	439.58
Montana	40.26	343.61
Nevada	9.69	103.91
New Mexico	0.07	164.17
Oregon	51.73	516.61
Utah	26.01	285.00
Washington	4.24	188.30
Wyoming	61.10	234.90
Total	378.90	3,182.94
Eastern:		
Alabama	5.00	5.00
Arkansas		56.76
Florida		64.24
Georgia	9.96	18.59
Kentucky		
Maine		
Michigan		
Minnesota		34.57
Nebraska		
New Hampshire	1.35	3.59
New Jersey		
North Carolina	19.89	36.27
Oklahoma		
Pennsylvania		
Porto Rico		
South Carolina		5.27
South Dakota	6.75	41.51
Tennessee	25.60	37.83
Virginia	5.40	11.88
West Virginia		
Total	73.95	315.51
Grand total	452.85	3,498.45

Other important highways completed during the year include the Saxman-Mountain Point section of the Tongass Highway in Alaska; the Cherry Creek Hill section of the Salt River-Pleasant Valley Highway in Arizona; the Camp Rock section of the Independence Pass Highway in Colorado; the Crooked Fork section of the Lewis and Clark Highway, the Peasley

Creek section of the Elk City Highway, and sections 1, 2, and 3 of the Salmon-Montana Line Highway in Idaho; the Garry section of the Columbia Falls-Glacier Park Highway in Montana; the Schofield section of the Scottsburg-Reedsport project and the Fall Creek section of the Alsea River Highway in Oregon; and the San Francisco River bridge on the Datil-Reserve-Dry Creek Highway in New Mexico.

A number of previously graded projects were surfaced during the year. Among these the most important were the Snowflake-Pinetop project in Arizona; the Warm River-Yellowstone project in Idaho; the Austin-Unity section of the Prairie City to Unity project and the Cloud Cap Inn project in Oregon; and the Shuksan-Austin Pass section of the Mount Baker Highway in Washington.

By agreement with the Governor of Alaska and the Forest Service, the bureau has undertaken a survey of the highway needs of those sections of Alaska located within and adjacent to the national forests. One of the principal purposes of the survey is to ascertain what may and should be done by highway construction to develop the mineral deposits, forest resources, water-power, and other natural possibilities of southeastern Alaska. This region at present is inaccessible even to prospectors, and it appears that the construction of a few low-type roads will do much to facilitate a proper development.

It will not be possible in all cases to predict that such roads as may now be built will continue in the future to serve adequately the needs of the developed territory, but every effort will be made to provide for future as well as immediate needs. So far as possible, the roads will be so located that they will continue to meet the highway requirements of the section in the future if surfaced and otherwise further improved in accordance with traffic demands. In some cases the roads at first constructed may prove to require relocation after the pioneer period, but it is hoped by a very thorough study of the region to anticipate the direction of development and so avoid the necessity of subsequent relocation as far as possible.

In order more effectively to cooperate with the Territorial authorities in the survey and in the construction of the roads, the bureau has established a district office at Juneau, and the district engineer has been authorized to undertake the survey in conjunction with representatives of the Territory. It is expected that the roads found to be needed will be constructed with forest-highway funds.

Since entering into agreement with the National Park Service of the Interior Department to assist that service in the survey and construction of roads in the national parks there have been completed under the bureau's supervision approximately 74 miles of national-park roads and at the close of the year construction was under way on 103 miles additional. Besides this work of construction, the bureau has also made surveys of an extensive mileage and surveys of 233 miles are at present actively in progress.

The longest sections thus far completed are in Crater Lake, Sequoia, and Yosemite National Parks. Others have been completed in Glacier, Mount Rainier, Grand Canyon, Lassen Volcanic, General Grant, and Rocky Mountain National Parks.

The work at present under construction is in the same parks, with the exception of General Grant, and in addition there are approximately 7 miles in Hawaii.

One of the most interesting of the national-park projects is the work on the Transmountain Highway in Glacier National Park. Here is a road in which practically every conceivable obstacle has been met and overcome. The 16-foot roadway is being literally hewn out of the solid rock of the Garden Wall in order to reach and cross the Continental Divide. The west side section, which has been under construction for some time, is 15.7 miles long, and the cost of grading and surfacing with crushed stone will probably be about a million dollars. At the close of the fiscal year work on this section was about two-thirds completed.

In Mount Rainier National Park work is in progress on the Nisqually Road. Three bridges have been completed on this road at a cost of more than $66,000, and the Longview section, 11.77 miles long, is nearly completed. The improvement on this section consists of grading and crushed-rock surfacing to a width of 18 feet, at a cost approaching $280,000. The Round Pass section of the West Side Highway in this same park is also under construction, the improvement consisting of 10 miles of grading and 16-foot crushed-rock surfacing. The indicated cost of this road is over $400,000, but it was only about one-eighth completed at the close of this fiscal year.

The El Portal-Floor of the Valley Highway in Yosemite is another million-dollar project. The improvement here

is of a higher type than in the cases previously mentioned on account of the heavier traffic. Two sections of the road are under construction, the first involving the laying of an 18-foot bituminous-concrete surface on 13.63 miles, and the second consisting of the grading of 13.79 miles and subsequent surfacing with bituminous macadam.

At the Grand Canyon work is under way on both the north and south rims. In Rocky Mountain National Park the grading of the 7-mile Bear Lake project is almost half completed, and in far-away Hawaii the Chain of Craters project, involving nearly 7 miles of grading and gravel surfacing, is well under way.

These are merely a few of the important roads now under construction in the parks. When they are completed they are likely to be rated among the most interesting tourist roads in America, and the Zion Canyon Road in Utah, shortly to be started, is destined in many ways to surpass them in interest.

RESEARCH

The research activities of the bureau are carried on principally by four divisions, namely, the division of tests, which is responsible for physical researches in the highway field; the division of economics and highway transportation, which has charge of traffic surveys and other economic studies of highways and their use; the division of control, which makes studies of the efficiency of highway construction and maintenance operations; and the division of agricultural engineering, which conducts numerous researches in connection with the application of engineering principles to agriculture.

The line of demarcation between the respective fields of these research divisions can not be sharply drawn. Even the work of the division of agricultural engineering, between which and the other divisions there is less in common than the others have between them, deals with questions which are also under investigation from other points of view by the highway research division. For example, the agricultural engineering division has under way studies of the permeability of soils, the run-off of rainfall from the surface of the land, the flow of water in pipes and flumes of various materials, the effect of alkali and soil acids on concrete, the drainage of soils, the economy of transporation by motor vehicle and other means, all of which are of interest in somewhat different application to those who are studying problems of the highways, and, as previously stated, the proper work of the three highway divisions even more frequently runs along parallel lines.

In order to prevent undesirable duplication of effort and to facilitate cooperation between these four divisions and also to bring to bear upon their work and its results the constructive criticism of those in other branches of the organization whose duties have to do with the application and dissemination of the results of research, there has been created during the past year a research committee. Its membership is composed of the heads of the four research divisions, the chief of the division of design, and the two assistants to the chief of bureau. This committee considers all research projects before they are undertaken, with a view to ascertaining whether they are of sufficient importance to warrant the expenditure of effort and funds required, reviews all results obtained from the work undertaken, and endeavors to promote harmonious and mutually helpful cooperation between the several divisions. Its recommendations are made to the chief of bureau, who takes such action as seems desirable in the circumstances.

The fundamental researches into the magnitude and effects of motor-truck impact and the characteristics of soils as highway subgrades have been carried on with satisfactory results throughout the year and will be continued.

IMPACT INVESTIGATIONS

In the impact investigation attention has been directed during the year mainly to the study of the effects of road roughness and of the characteristics of the springs and tires of vehicles. This phase of the work has been conducted in cooperation with the Rubber Association of America and the Society of Automotive Engineers, and information has been obtained which will be useful to manufacturers of rubber tires and vehicles in the development of refinements of vehicular design which will tend to reduce the impact applied to the road and correspondingly reduce the shocks reacting against the vehicles and their passengers.

As the year drew to a close arrangements were being made to test the effects of various types of cushion wheels now offered by manufacturers, and also to ascertain with greater certainty the relative impact resulting from corresponding drops of a wheel on different types of highway surfacing and pavement. Interest in this latter

connection lies especially in a comparison of concrete pavements and pavements constructed with an asphaltic top on a concrete base. Information of this character is needed to permit these competing types of pavements to be considered upon a basis of comparable strength.

SUBGRADE STUDIES

In the subgrade-soil investigation very promising progress has been made in the development of tests by which the properties of the soils which affect their value as subgrade materials may be measured, and plans have been perfected for extensive soil surveys to be made with the assistance of the State highway departments and the Bureau of Chemistry and Soils.

The information already collected by the Bureau of Chemistry and Soils will be used as the starting point in these surveys, and will be extremely valuable. The principal object of the new surveys will be to ascertain the value of the soils—previously classified with respect to their agricultural possibilities—as road subgrades. This will be accomplished by accumulating evidence of the behavior and condition of pavements laid upon them, as well as by tests of the soils themselves by the methods now being perfected.

The purposes and aims of the bureau in making these subgrade studies may be briefly stated as follows:

1. To determine the practicability of varying the type or design of road surface to suit subgrade conditions.

2. To ascertain the efficiency of various methods of drainage and subgrade treatment and types of subbase.

3. To determine the relative economy of subgrade correction (treatment, drainage, or subbase) and change in pavement design (type, thickness, or other features) as compensation for varying subgrade conditions.

As indicating the large savings that may be possible as the result of the adjustment of the surfacing material or pavement to the particular characteristics of various subgrades when these characteristics and their effects are understood the following instances are of interest.

On the Maryland highway between Beacon Hill and Elkton about 30 per cent of one section of the concrete pavement is badly broken while an adjoining section is intact. The difference in conditions has been definitely traced to the character of the subgrade under the two sections. If these differences had been fully understood and compensated for in the design of the pavement on the two sections a considerable loss could have been avoided, and similar losses could be prevented in other sections.

East of Cleveland, Ohio, brick surfaces laid on 4-inch concrete base have given satisfactory service for years, while a similar surface laid on a 6-inch base south of the city has proved inadequate. The difference is again a question of subgrade support, and there is involved in the proper answer to the question a sum amounting to several thousand dollars a mile.

Finally, as indicating the possibilities of subgrade treatment reference may be made to a section of gravelly soil road treated with bituminous materials in New Hampshire, which has accommodated traffic through two winters, in contrast with other untreated sections of the same road into which the wheels of vehicles have sunk to their hubs. The additional support afforded by the treated soil is plainly indicated, and the difference is such as to warrant a material reduction in the thickness of surfacing material or pavement if such were required for the accommodation of traffic.

LIGHT OIL TREATMENT OF CRUSHED ROCK

Of immediate interest to the Western States is an investigation which has been carried on jointly during the past year by the bureau and the California State Highway Commission, the purpose of which is to estimate the possibilities of developing a type of surfacing for roads of intermediate traffic density by the treatment of crushed-rock and gravel roads with light "fuel oils." If the treatments which are now being applied experimentally on many miles of highway in Oregon and California and other Western States should in the long run prove as satisfactory as the experience to date indicates, these methods will doubtless provide a key to the serious problems of county and local road improvement in many other parts of the country.

The use of fine crushed-rock and gravel surfaces on lightly traveled western roads has been mentioned in previous annual reports. Many miles of such surfaces have been laid on roads which obviously required some improvement beyond grading and drainage, and it has been found that they are subject to two serious objections. In the first place, they are very dusty, and in the second, they are so rapidly worn down by the wheels of vehicles that as much as an inch or

more of metal may be lost in a single year.

In the effort to eliminate the dust nuisance and reduce wear, methods of treating such surfaces with light fuel oils have been developed which not only accomplish the results initially sought, but which, it now seems, will produce road surfaces of exceptional smoothness and high service value.

With the cooperation of the California commission examples of this type of improvement have been carefully studied during the past year and a report has been prepared which will shortly be placed in the hands of highway officials throughout the country in order to draw attention to the possibilities of the treated roads and to disseminate a knowledge of certain essential principles upon which their successful construction appears to depend.

CONCRETE ARCH BRIDGE TEST

During the year there was presented to the bureau an unusual opportunity to test to destruction a large concrete arch bridge of modern construction in North Carolina. The design of concrete arches has been developed largely on the basis of theoretical analysis and tests of model bridges, and while the methods devised have been generally satisfactory there has been no opportunity to verify them by comparison of computed stresses under maximum loads with the actual stresses developed under such loads.

The bridge upon which it has now become possible to make such a comparison was built in 1922 over the Yadkin River in North Carolina as a Federal-aid project. All details of the design are therefore well known to the bureau. A dam now under construction downstream will soon submerge the bridge and it has become necessary to replace it; consequently it may be tested to destruction, and this will be done by the bureau in cooperation with the North Carolina State Highway Commission and with the advice of national engineering and scientific associations and other interested agencies.

The bridge consists of three open-spandrel arch spans of about 150 feet each and 14 T-beam or deck-girder spans of approximately 40 feet each, making an overall length of 1,069 feet.

By the end of the year an advisory committee representing the agencies mentioned had been formed, and plans had been worked out in detail for the tests which will be begun as soon as it becomes possible to divert traffic. Large water tanks have been made ready for the application of load, instruments and procedure have been decided upon, preliminary temperature stress measurements have been made, and it is expected that the tests under load will be begun in October.

This is an exceptionally important test, the results of which will be of great value to the engineering profession as a whole, and it will be watched and studied with corresponding interest.

TRAFFIC SURVEYS

Traffic surveys similar to those conducted previously in cooperation with the authorities of Maine, Connecticut, Pennsylvania, Ohio, and Cook County, Ill., have been carried on during the past year in New Hampshire and Vermont in cooperation with the respective State highway departments. Reports which will serve as the basis of the planning of future highway improvements have been prepared and will shortly be printed.

The value of these surveys as a means of assuring the proper adjustment of expenditure and highway design to actual present and estimated future traffic requirements can scarcely be overrated.

The traffic-flow maps and other evidence of the character, weight, and usage of vehicles developed from the surveys present to those charged with the administration of the work of highway improvement a picture of the relative importance of the various roads which permits of the preparation of sound budgets and adequate highway designs and also makes possible the scheduling of improvement of each section of highway with respect to others in the order of their true traffic importance.

CONSTRUCTION-EFFICIENCY STUDIES

Continuing the studies of the efficiency of road-construction processes reported last year, attention has been directed this year to the analysis of power-shovel operation. The cost of grading is perhaps the largest single item in the highway bill of the country, and a great deal of the grading is done with steam and gasoline shovels.

The operation of these important tools involves a number of repetitive operations. The dipper must be loaded, swung, and spotted over the hauling unit, the load dumped, and the dipper returned for another load. From time to time the shovel must be moved for-

ward or maneuvered to keep it within digging reach of the material in which it is working. The hauling equipment—wagons or trucks—must be brought into position by the side of the shovel and loaded; they must then move to dump, deposit their load, and return to the shovel for another, turning and maneuvering in order to get within convenient reach of the shovel arm. As these operations are repeated over and over again throughout the day, a few seconds or even fractions of seconds regularly lost in any part of the operation, or any failure properly to adjust the hauling equipment to the capacity of the shovel, inevitably results in a loss in productivity which soon mounts to large proportions.

As in the other efficiency studies previously conducted, the various phases of power-shovel operation have been analyzed with a stop watch and the time required for efficient operation has been determined. Testing by these standards the operation of shovels by contractors under various conditions, it is found to be possible, by good management, to make material improvements in efficiency in most cases.

The facts developed in these studies will shortly be published in the bureau's periodical Public Roads, and the information will also be disseminated to contractors and engineers by papers in the engineering and contracting publications, by addresses before associations of contractors and engineers, and in other ways.

The efficiency studies involving, as they do, an intimate study of the details of road-construction processes afford an excellent opportunity for the training of young engineers, and they are being so utilized. Every spring a number of junior students in the engineering schools are selected for employment during the summer as assistants in the studies. Working under careful direction, these young men receive a practical knowledge of road construction which constitutes a very desirable supplement to their theoretical training. Upon graduation a year later those that have manifested the highest proficiency and fitness are permanently employed and their training is continued, first in connection with the efficiency studies and later in other branches of the work of the bureau, after which they are assigned to regular duty in the work for which they have shown the greatest fitness. In this way a corps of thoroughly trained young engineers is being developed from which to fill vacancies as they occur in the higher positions of the bureau and the State highway departments.

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., September 1, 1928.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1928, covering the work done in connection with the construction of Federal-aid, national-forest, and national-park roads, the economic and physical researches in connection with problems of highway improvement, and the research and other work of the division of agricultural engineering.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

Hon W. M. JARDINE,
Secretary of Agriculture.

During the fiscal year 1928 improvements were completed on 8,184 miles of Federal-aid road which had not previously been improved with Federal assistance. Advanced stages of improvement were completed during the year on 2,014 miles. At the close of the year initial improvements were in progress on 9,494 miles and advanced or stage construction was under way on 1,285 miles.

All of this work was or is being done on roads which are parts of the Federal-aid highway system, consisting of 187,753 miles of main interstate and intercounty highways.

The total mileage initially improved with Federal aid since the beginning of the Federal cooperation is 72,394 miles. As the original length of these roads has been shortened by subsequent relocations by a total of 34.4 miles throughout the entire period, and as there is a portion of the total amounting to 1,285 miles which is now undergoing stage construction, the mileage classified as completed at the close of this fiscal year is 71,074 miles.

By the completion of 281 miles during the fiscal year the mileage of completed roads built in cooperation with the Forest Service under the bureau's supervision in the national forests is brought to 3,775 miles. Of this total, 3,484 miles are in 12 Western States and the Territory of Alaska and 291 miles are in 11 Eastern States. These improved roads are portions of the forest-road system which has been designated jointly by State and Federal authorities and which embraces at present a total of 13,911 miles, of which 11,768 miles are in the above-mentioned 12 Western States and Alaska.

Continuing the cooperation with the National Park Service of the Department of the Interior, the bureau has surveyed, planned, and supervised the construction of important roads in the park areas. Working in accordance with a program that calls for the improvement of over 1,500 miles, the result to date is 120 miles built, 164 miles under construction, and an additional 322 miles of survey in progress.

The bureau's connection with the Federal aid, national forest, and national park road work places it in a position where it is able to serve as a correlating agency to give common direction to these three major road activities of the Federal Government. Its exercise of this function is especially needed in the Western States in

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which the reserved national areas are largest and most numerous. In these States the intermeshing of the roads in the forests, parks, Indian reservations, and other national areas with the roads of the States outside the borders of the national lands is essential to the development of an adequate highway system. The bureau has accepted the responsibility for accomplishing this result, and the articulation of the Federal aid, national forest, and national park road systems, which constitute the definite programs of future endeavor in the three major classes of road work of interest to the Federal Government, testifies to the success of its efforts. The similar exercise of its coordinating influence in the construction of the roads of all three is bearing fruit which is recognizable in the higher and more uniform standards that now prevail throughout all States and in the development of all highway systems. These very satisfactory results have been achieved through the mutual cooperation of Government bureaus and the pooling of Federal and State effort, and it is gratifying to be able to report them in view of the present widespread interest in rational governmental coordination.

The application of similar methods of intermediation and coordination is largely responsible for the significant success which has attended the bureau's most important economic research project of the year—the planning of a highway system which will relieve traffic congestion in the metropolitan region about the city of Cleveland, Ohio. In the area affected by highway traffic originating in and destined to Cleveland there are parts of seven counties. In Cuyahoga County alone there are 4 cities, 49 incorporated villages, and 6 townships, a total of 59 more or less independent jurisdictions, each possessed of authority over the highways within their borders. Faced by a common problem—the provision of adequate arteries for the flow of the increasing traffic of a great metropolitan area—the authorities of the several jurisdictions had been unable to agree upon a concerted plan, and their independent and frequently conflicting efforts had failed to produce a satisfactory solution.

At the request of the board of county commissioners of Cuyahoga County, the bureau agreed to undertake a survey of the highway traffic of the area and on the basis of fact thereby developed to plan a consistent program of improvements designed to relieve the congestion that had arisen, on one condition, namely, that the authorities of each of the jurisdictions involved would agree to carry out the plan presented and adopted. The condition was accepted, the survey has been made, and a plan of improvement has been drawn up which has met with the enthusiastic indorsement of all authorities. As the fiscal year closes, work is already under way to put into effect some of the more important recommendations, which, if carried out, will doubtless strike at the root of the traffic troubles of the area.

In the department of physical research the study of the characteristics of road-surfacing materials and subgrade soils and the measurement of the natural and vehicular forces to which the roads are subjected have been carried on with all possible vigor. The problems involved are exceedingly complicated and the necessary duration of the studies correspondingly long. The variables are being attacked one by one; and each year adds to the fund of knowledge which is gradually evolving rational bases of highway design, and which ultimately may be expected to eliminate doubt, to the extent that it is ever possible to do so in works subjected to natural forces, as a factor in the work of highway improvement.

Of far-reaching importance are the investigations which have for their purpose the development of types of road surface low in cost and yet capable of bearing the year round, without dust in summer and mud in winter, the light traffic which must be accommodated by hundreds of thousands of miles of local roads. The investigations in this field, conducted by the bureau in cooperation with the highway departments of California and South Carolina, have had results of great promise and utility.

The treatment of fine crushed gravel and rock roads with asphaltic fuel oils, by methods modified and improved as a result of the cooperative investigation with California, has been especially effective in the arid and semiarid Western States where, on untreated stone roads, the dust nuisance had become intolerable. Already 2,500 miles of crushed-stone roads have been treated by this method in 9 Western States, and when the season's current program is completed there will be over 3,000 miles in 11 States. The treatment strikingly improves the riding qualities of the roads, completely eliminates dust, and reduces surface

wear to a negligible quantity at a cost which, under efficient management, does not exceed $1,700 a mile.

In the South Carolina investigations the aim is to develop a similar treatment which will be applicable to various earth and stone surfaces and which will produce satisfactory results in the more humid sections of the country.

The test of the concrete-arch bridge over the Pee Dee River near Albemarle, N. C., of which mention was made in the report for the preceding fiscal year, has been completed, and the analysis of the data obtained is nearing completion. This test, which was conducted cooperatively by the bureau and the North Carolina State Highway Commission, has commanded the interest of bridge engineers throughout the world.

The importance of the test is due to the fact that it offers an unparalleled opportunity to verify the accuracy of the accepted design theory by a comparison of theoretical stresses with those actually produced by test loads. The results will have great scientific value and it is expected that they will point the way to a more accurate and economical proportioning of structures of this type.

The efforts to promote efficiency and economy in road construction operations, begun several years ago, have dealt this year particularly with three questions: (1) The possibilities of economy in the operation of power shovels used in grading; (2) the effect of the length of mixing time on the strength of concrete mixed in standard highway paving mixers, and the possibility of effecting economies by reducing the length of the mixing period, and (3) the possibility of producing asphaltic and bituminous concrete surfaces of greater smoothness and lower cost by the use of mechanical finishing methods.

The first two lines of study have been carried to the point of establishing with considerable conviction just what economies may be effected without detracting from the service qualities of the roads. The latter, which was begun coincidently with the first experimental uses of finishing machines on bituminous surfaces, has been an invaluable guide in the perfection of the machines and methods of operation, and is being continued with a view to promoting still further efficiency in this most recent application of mechanical power to road construction.

Seeing what is believed to be a serious menace to the free flow of highway traffic in the extraordinary activity of promoters of private toll bridges on important State and interstate arteries, the bureau undertook an investigation of the situation, which was completed during the past year. The investigation disclosed the number and location of toll bridges already in operation and under construction and showed that a majority are on the Federal-aid highway system. It directed public attention to the alarming increase in the number of applications for legislation permitting the erection of such bridges; and pointed out the alternative means that might be adopted to provide needed bridges by public initiative and thus prevent the private exploitation of highway facilities built so largely at public expense. In fairly and wisely meeting this situation the administrative authorities of the States and Federal Government need legislative support which it is confidently expected will not be denied.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

In the Federal-aid highway system, designated as required by the act of November 9, 1921, there are at present 187,753 miles of main interstate and intercounty highways. All Federal funds appropriated since the passage of the act have been applied to the improvement of this limited system. As a result of this wise policy continuously followed for eight years the major highway system of the Nation has been steadily improved, and the independent efforts of the States applied to the same system have furthered the results of the cooperative undertakings; so that initial improvements have now been made on more than three-fourths of the entire mileage.

The cooperation with the States has this year added the initial improvement of 8,184 miles, increasing the total mileage upon which improvements have been completed from the 64,210 miles of a year ago to 72,394 miles. The latter figure represents the total mileage initially improved since the inception of the Federal-aid policy in 1916. With the exception of a small amount of work done before the passage of the act of 1921, all of this mileage is included in the Federal-aid system.

By relocations made in the course of subsequent construction this initially improved mileage has been reduced by

approximately 34 miles, and there are at present 1,285 miles which, because they are now undergoing further stages of improvement are temporarily transferred from the classification of improved mileage. With these deductions the total mileage class fied as improved stands at 71,074 miles.

A year ago the mileage reported as initially improved was 64,210 miles. This included 1,213 miles which were then undergo ng stage construction and nearly 23 miles, the aggregate shortening of the routes resulting from advanced improvements up to that time. With these deducted the total classified as improved was 63,974 miles. Comparing this figure with the 71,074 miles now classified as improved, after taking account of reductions in the length of routes and sections of previously improved road now undergoing further improvement, it will be seen that the increase in the improved mileage classification is 8,100 miles.

Exact figures representing the mileage in the system improved by the States without Federal assistance are still unava lable; but reliable estimates by State highway officials ind cate that the total exceeds the mileage improved with Federal aid; and it is probable that the aggregate length of a'l sections initially improved to date is not far from 150,000 miles.

ADVANCED IMPROVEMENTS MULTIPLY

While init'al improvement has thus been extended to a very large portion of the designated system, advanced or so-called stage construction has been carried on on sections of road already initially improved where traffic growth has demanded and available funds and sound public policy have permitted.

As the minimum traffic requirements are met by the extension of initial improvement to a constantly increasing mileage it becomes possible to direct the available resources of money, men, and materials in increasing measure to the further betterment of the initially graded or lightly surfaced roads and to refinements of grade, location, and design which were deliberately omitted in the first stage of improvement in order to make limited resources go as far as possible.

Such further improvements were completed during the past year on 2,014 miles of highways previously improved with Federal aid. This work does not increase the total of mileage improved. In fact, it generally has the effect of slightly decreasing the mileage of improved road in the system by the amount of the shortening in distance which results from relocations found to be possible and desirable.

During the past year the mileage of improved road in the Federal-aid system was decreased by such relocations and other revisions by a total of about 11 miles, which, added to similar reductions previously effected and totaling approximately 23 miles, brings the total shortening of distance to about 34 miles

But, although the stage-construction work does not add to the total of mileage improved, it does add to the work accomplished; and the mileage dealt with this year amounts to nearly a fourth of the mileage initially improved. If the mileage on which stage construction was completed during the year is added to the mileage initially improved in the same period, the total mileage upon which work has been comp'eted during the year is found to be 10,198 miles. As the corresponding figure for the preceding year was 9,683 miles, it is apparent that the work done during the past year considerably exceeded the accomplishment of the preceding year.

The tendency to devote greater attention to stage construction as the initial improvement of the system nears completion is indicated by the fact that, whereas the mileage thus further improved during the fiscal year 1927 was about 16 per cent of the mileage of initial improvement completed, the corresponding ratio for the past year's work was nearly 25 per cent. It is further illustrated by the fact that the mileage of stage construction completed during the past year exceeded by over 600 miles the completed mileage of similar construction in the preceding year, which far exceeded the similar work done in previous years.

The subsequent improvements invariably enhance the service value of the highways. They consist generally of the application of a surface to a previously graded road or the substitution of an improved surface for a previously placed surface of lower type. In some cases the improvement involves relocation of the highway as originally built, to rectify alignment, eliminate grade crossings of railroads, or for other purposes.

Considered in the aggregate, the effect of the stage construction is to raise gradually the standard of improvement upon the system as a whole and this, despite the fact that the progress of

initial improvement is adding to the completed mileage each year a large mileage of graded and drained roads and roads temporarily surfaced with low-grade material. Thus, in the past year initial improvement added to the improved mileage 2,182 miles of graded and drained earth roads without surfacing of any sort. But in the same period, previously built earth roads were surfaced by stage construction so that the net increase in the mileage of unsurfaced roads was only 685 miles. And, whereas the high-type pavements of brick, concrete, and bituminous concrete, completed as initial improvements during the year was 2,711 miles, the net increase in mileage of these high types was 3,336 miles, the differential being the contribution of stage construction.

Slowly but surely the general level of improvement of the system is being raised in this way even while the pioneering effort still adds largely each year to the mileage improved by low types. Whereas graded and drained earth roads two years ago made up more than 17 per cent of the entire improved mileage, they now constitute only 15 per cent. Where two years ago the mileage of pavements completed was less than 26 per cent of the total completed mileage, to-day it approaches 29 per cent.

TYPES OF FEDERAL-AID ROADS

The 8,184 miles of initial improvement completed during the year include 2,182 miles of graded and drained earth roads, 844 miles of sand-clay roads, 1,836 miles of gravel roads, 92 miles of water-bound macadam roads, 464 miles of bituminous macadam roads, 136 miles of bituminous concrete pavement, 2,533 miles of Portland cement concrete pavement, and 42 miles paved with vitrified brick. The remaining 54 miles were made up of numerous bridges and their approaches, each structure being more than 20 feet in length.

Determination of the surface type of the roads built, responsibility for which is shared by the Federal and State authorities, rests primarily upon the needs of the traffic carried by each individual section of road. This primary consideration is modified to a degree by the desirability of extending some measure of improvement as rapidly as possible to the entire highway system.

Notably in the States of the South and West, by reason of their large size, their comparative sparsity of population and limited public revenues, and the less advanced stage which characterizes the development of their highway systems, these further considerations appeal with much force. Consequently it will be found that in these States the initial improvements include, in greater proportion than in the Eastern and Northern States, the lower types of surfaces. That such considerations have not induced the construction of types of surfaces clearly out of accord with the demands of traffic is indicated by Table 1, which presents an analysis of the proportions of low and high types of surface construction in the several geographic regions in relation to the general density of motor-vehicle traffic, as roughly expressed by the number of registered motor vehicles per mile of the Federal-aid highway system in each region.

TABLE 1.—*Relation of the types of initial improvements completed during the fiscal year 1928 and the general density of motor-vehicle traffic on the Federal aid highway system by groups of States*

Group of States	Number of motor vehicles per mile of Federal-aid system [1]	Percentage of mileage of initial improvements completed	
		Bituminous macadam and higher types	Water-bound macadam and lower types
Middle Atlantic	362	91.4	8.6
New England	241	78.3	21.7
Pacific	219	44.5	55.5
East North Central	203	75.2	24.8
South Atlantic	102	62.1	37.9
West South Central	83	36.1	63.9
East South Central	72	21.0	79.0
West North Central	67	16.4	83.6
Mountain	36	2.4	97.6
All States	123	38.8	61.2

[1] As registered in the several States during the calendar year 1927.

As would naturally be expected from the foregoing statements, Table 2 shows that the mileage of stage construction or advanced improvements completed is greatest in the West and South and least in the wealthy, populous, advanced, and territorially limited States of the Middle Atlantic and New England groups.

TABLE 2.—*Mileage of stage construction completed during the fiscal year 1928, by groups of States*

Group of States	Mileage of stage construction completed during the year	Percentage of the total
New England	0.0	0.0
Middle Atlantic	3.0	.1
South Atlantic	186.8	9.2
East North Central	40.3	2.0
East South Central	96.0	4.8
West North Central	1,214.8	60.3
West South Central	286.5	14.3
Mountain	148.2	7.4
Pacific	38.6	1.9
All States	2,014.2	100.0

Roads included in the Federal-aid system are by and large the most heavily traveled in the United States. They are the main interstate and intercounty roads and are included in the designated mileage for this reason. In the States in which traffic surveys have been made by the bureau it has been possible to measure the relative traffic importance of the Federal-aid roads and other roads of the States, and these determinations have shown invariably the greater utilization of the Federal-aid system.

In Vermont the average traffic on all roads of the Federal-aid system was found to be 702 vehicles per day. The traffic on all other numbered State routes (the most important State roads outside the Federal system) averaged 293 vehicles per day.

In New Hampshire the observed traffic on the Federal-aid roads averaged 1,088 vehicles per day; on other State trunk lines it averaged 551 vehicles per day.

In Ohio the Federal-aid roads carried in 1925 an average of 708 vehicles a day, and other roads of the State highway system showed a daily traffic average of 538.

The Connecticut survey in 1923 indicated an average traffic utilization of the Federal-aid system exceeding by 15 per cent the average for the entire State system.

The types of road surface that have been found by experience and test to be especially suitable for dense and heavy traffic are bituminous macadam and the several pavement types. This being true, the mileage improved with Federal aid should show a greater percentage of these higher types of surface than other improved State roads. That this condition actually exists is indicated by the analysis presented in Table 3, where the surface types of completed Federal-aid roads are compared with those of all other State-built roads. Table 3 is merely indicative of the superiority of improvements on the Federal-aid system. A considerable part of the mileage built by the States without Federal aid is also on the Federal-aid system. If it were possible to separate this mileage from that not included in the system it would doubtless show a type classification similar to that of the roads built with Federal aid, and the percentage of the higher types on the remaining portion of the State systems would probably be lower than the percentage shown by Table 3 for all unaided construction.

TABLE 3.—*Percentages of high and low types of surfaces on Federal-aid roads completed to June 30, 1928, and State roads built without Federal aid to December 31, 1927*

System	Water-bound macadam and lower types, percentage of total	Bituminous macadam and higher types, percentage of total
Federal-aid roads	65.2	34.8
State roads (exclusive of roads built with Federal aid	[1] 73.9	[1] 26.1

[1] These percentages are obtained by subtraction of the mileage of Federal-aid roads completed to June 30, 1928, from the mileage of all State roads completed to Dec, 31, 1927. The interval of six months and the fact that a small mileage of Federal-aid roads is not included in the State systems have no material effect upon the percentages.

The response to the increasing demands of a growing traffic is shown by the greater increase in the types more suitable for heavy traffic. With regard to the Federal-aid roads this fact is evidenced by Table 4, which shows that the net result of the last-year's work was to increase the mileage of completed high types of road by 19.3 per cent, while the mileage of completed low types increased but 9.7 per cent.

Combining to produce this result there are the two policies of opposite tendency; on the one hand the policy of extending pioneer improved mileage as rapidly as possible by construction of low type, and on the other the upbuilding policy of stage construction. The effect of the latter policy is indicated by the fact that although the year's

initial construction added to the completed mileage 2,182 miles of unsurfaced earth roads and 2,553 miles of concrete pavement, the net increase in the completed mileage of earth road was only 685 miles, while the net increase in the mileage of concrete pavement was 3,131 miles.

TABLE 4.—*Mileage of the several types of Federal-aid roads improved at the close of the fiscal years 1927 and 1928 and percentage of increase*

Type	Mileage at close of fiscal year 1927 [1]	Mileage at close of fiscal year 1928 [1]	Percentage increase during fiscal year 1928	
Graded and drained	9,926.6	10,611.3	6.9	
Sand-clay	5,578.9	6,470.9	16.1	
Gravel	25,337.7	27,698.3	9.3	9.7
Water-bound macadam	1,300.1	1,426.6	9.7	
Bituminous macadam	3,670.0	4,317.2	17.6	
Bituminous concrete	1,834.3	1,993.3	8.7	19.3
Portland cement concrete	14,385.7	17,516.3	21.8	
Brick	771.8	817.9	6.0	
Total	62,805.1	70,851.8	12.8	

[1] Mileage under stage construction at the close of the year and reductions in mileage by relocation, etc., deducted from total mileage completed.

The 2,182 miles initially improved by grading and draining and the additional mileage initially improved with low-type surfaces constitute a very considerable betterment of the preexisting conditions. These initial improvements will serve present traffic with at least a fair degree of satisfaction, and the service will be improved by stage construction if and when it is required within the limit of funds available. If in the initial improvement the several types had been represented in the same proportions as their net increases during the year, a certain mileage, possibly as much as a thousand miles, that has been improved to a measurable degree would still be wholly unimproved

FEDERAL-AID BRIDGE CONSTRUCTION

The Federal-aid bridges completed during the year, with their approaches, have an aggregate length of over 54 miles. In the preceding year the aggregate length of the structures completed was not quite 46 miles, and this was more than twice the mileage completed during the fiscal year 1926. The year's results in bridge construction, as will be seen from these comparisons, are worthy of special note.

The bridges under construction and approved for construction at the close of the year have, with their approaches, an aggregate length of nearly 68 miles, exceeding by more than 3 miles the total length of structures in the corresponding stages of progress at the beginning of the year.

Including the structures just completed, the Federal aid bridges now standing have a total length, with their approaches, of 222.5 miles, nearly a fourth of which was added during the last year.

All of these structures are more than 20 feet in clear span, and in several instances the structures with their necessary approaches span distances of a mile and more.

A list of the bridges completed during the year which cost $75,000 or more is given in Table 5. These, the longest and most expensive of the projects completed, vary in length from about a tenth of a mile to a mile and more, and have an aggregate length of 29.6 miles. The remainder of the mileage completed is made up of numerous smaller and less expensive bridges. The total number of bridges of all lengths from 20 feet upward completed during the year for which the final Federal payment has been made is 1,544.

TABLE 5.—*Federal-aid bridges completed during the fiscal year 1928 at a cost of $75,000 or more each*

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
				Miles
Arizona	Between Phoenix and Yuma	Gila River	$317,400	0.3
California	Between Redding and Yreka	Dog Creek	119,600	.1
Do	Between Los Angeles and Whittier	Rio Hondo River	91,600	
Do	Between Santa Barbara and San Luis Obispo.	Santa Maria River	110,400	.4
Do	Between Los Angeles and Santa Ana	Santa Ana River	98,800	.1
Do	Between American River and Sacramento County line.	Underpass, Southern Pacific R. R.	77,500	.3
Colorado	Between Craig and Meeker	Yampa River	89,500	.9
Connecticut	At Gaylordsville	Housatonic River	111,800	.2
Do	Between Norwich and Putnam	Overhead bridges and approaches over N. Y., N. H. & H. R. R.	87,900	.2
Do	Between Hartford and Meriden		160,900	.8
Do	Between Hartford and Massachusetts State line.		124,500	.7
Florida	Between Pensacola and Milton	Escambia Bay and River.	983,400	3.5
Do	Between Brevard and St. Lucie Counties.	Sebastian River	226,800	.4
Georgia	Between Bainbridge and Brinson	Flint River	326,200	.4
Do	Between Abbeville, Ala., and Fort Gaines, Ga.	Chattahoochee River	169,900	.6
Do	Between Brunswick and Florida State line.	Satilla River	113,600	.1
Do	Between Lyons and Baxley	Altamaha River	202,000	.1
Do	Between Elbert County, Ga., and Abbeville County, S. C.	Savannah River	227,200	.3
Idaho	Between Sand Point and Washington State line.	Clark's Fork	209,000	.5
Kansas	Between Oklahoma State line and Winfield.	Arkansas River	84,700	.1
Kentucky	Between Prestonburg and Paintsville	Levisa Fork of Big Sandy River.	106,400	.1
Louisiana	Between Pearl River, La., and Logtown, Miss.	West Pearl River	132,200	.1
Do	Between Vinton and Sabine River bridge.	Eastern approach of Sabine River bridge.	520,200	2.9
Do	Between Houma and Morgan City	Bayou Boeuf	151,600	.1
Michigan	Between Monroe and Tecumseh	Underpass, Detroit, Toledo & Ironton R. R.	126,600	.3
Do	Between Hudson and Farmington	Overhead crossing, Pere Marquette R. R.	156,700	.1
Do	Between Plymouth and Detroit	Underpass, Pere Marquette R. R.	157,800	
Do	Between Flat Rock and Dearborn	Underpass, Detroit, Toledo & Ironton R. R.	222,500	.3
Mississippi	Between Gulfport and Bay St. Louis	Bay St. Louis	813,800	2.0
Do	At Columbus	Tombigbee River	156,900	.1
Missouri	At Fenton	Meramec River	108,100	.1
Montana	Between Polson and Kalispell	Flathead River	99,900	.4
Do	Between Laurel and Billings	Underpass, Northern Pacific Ry.	80,000	.4
Do	Between St. Regis and Missoula	Clark's Fork of Columbia River.	85,600	.1
New Mexico	Between Fort Sumner and Vaughn	Pecos River	123,300	.2
New York	Between Binghamton and Oneonta	Overhead crossing, New York, Ontario & Western Ry.	83,400	.5
North Carolina	Between Morehead City and Beaufort	Newport River (two bridges).	528,500	.6
North Dakota	Between Schafer and Sanish	Missouri River	436,600	.2
Do	Between Alexander and Williston	Missouri River	584,700	.3
Ohio	Corporation line at the city of Piqua	Overhead crossing, Baltimore & Ohio R. R.	128,600	.1
Oklahoma	Between Weleetka and Wetumka	North Canadian River	83,700	
Do	Between Pawnee and Ponca City	Arkansas River	256,100	.4
Oregon	Between Newport and Hebo	Siletz River	113,100	.1
South Carolina	Between Charleston and St. Andrews Parish.	Ashley River	1,122,000	.3
Do	Between Conway and Georgetown	Pee Dee River	396,700	1.7
Do	Between Manning and St. George	Santee River	432,100	1.8
Do	Between Fort Lawn and Lancaster	Catawba River	175,300	.8

TABLE 5.—*Federal-aid bridges completed during the fiscal year 1928 at a cost of $75,000 or more each*—Continued

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
				Miles
Tennessee	Between Humbolt and Jackson	Middle Fork of the Fork Deer River.	$83,500	0.2
Do	Between Newport and North Carolina line.	French Broad River	111,900	.3
Texas	Between Wichita Falls and Randlett, Okla.	Red River	310,700	.1
Do	Between Jefferson and Orange Counties at Beaumont.	Neches River	359,400	.6
Do	Between Orange County and Calcasieu Parish, La.	Sabine River	227,700	.2
Do	Between Palestine and Buffalo	Trinity River (two bridges).	161,700	.1
Vermont	At Brattleboro	West River	127,800	.3
Virginia	Between Warsaw and Tappahannock	Rappahannock River	403,200	1.0
Washington	Easterly city limits of Tacoma	Over Puyallup River and the Northern Pacific, Union Pacific, and Chicago, Milwaukee & St. Paul tracks.	693,400	.5
Do	Between Ellensburg and Quincy	Columbia River	668,100	.5
Do	Between Everett and Marysville	Four bridges over Snohomish River, Union Slough, Steamboat Slough, and Ebey Slough.	1,033,800	.9
West Virginia	Between Fairmont and Pruntytown	West Fork River	126,900	.1
Do	At Gauley Bridge	Gauley River	92,000	.1
Do	Between West Hamlin and Logan	Guyandot River	90,000	.6
Wisconsin	Between Milwaukee and Pewaukee	Milwaukee River	260,400	.1

In the preceding annual report the hope was expressed that the use of Federal-aid funds in payment of a part of the cost of important bridges would be continued and increased. The fact that the mileage of bridges now under construction and approved for construction is greater than it was a year ago is therefore distinctly gratifying.

The Federal appropriations may very appropriately be used for this purpose; and, so used, they offer an avenue of escape from the dilemma which confronts the highway departments of many of the States. Faced on one side with the need of expensive bridges to span large streams of important arteries, and on the other with a very natural public desire to have the limited current revenues cover as many miles as possible, the State agencies may be pardoned for indecision as to the expediency of spending in a few localities such large sums as the building of large bridges entails.

Taking advantage of this hesitation on the part of the public agencies, private promoters have been busy acquiring exclusive franchises to build bridges at commanding locations on the publicly built highways and, in compensation therefor, to levy toll upon the annually increasing number of travelers.

An investigation made by this bureau showed that on October 31, 1927, there were in operation, under construction, or proposed, in the United States 424 toll bridges, of which number 217 were on the Federal-aid highway system.

In the first session of the Seventieth Congress bills were introduced to authorize the construction of 122 new toll bridges and 67 were authorized by acts passed and signed by the President.

Practically three quarters of all these bridges in operation or projected are or will be operated by private interests. The bureau has reliable information that such interests have sought by various means to obstruct the construction of free or publicly operated toll bridges at commanding locations. They have sought to enjoin the construction of public bridges in the courts; and they have attempted and in some cases have succeeded in blocking legislation authorizing the construction of public bridges.

With the purpose of discouraging such imposition of tolls upon users of the highways built in part with Federal aid, the Federal law at first prohibited

the expenditure of any part of the appropriations made by Congress for the construction of roads which serve as the immediate approaches to toll bridges.

Recognizing later the occasional desirability of resort to the toll method of financing in the case of bridges built, owned, and operated by the public itself, the Congress, by amendment of the law, specifically authorized the expenditure of Federal appropriations in payment of half the cost of public bridges, the State's portion of which is to be met by toll collections; and Federal funds may also be used in the construction of approaches to such public toll bridges.

By taking advantage of this provision of the amended law a State can write off at once half the cost of much-needed large bridges. The remainder it can finance without incurring a public debt, in the constitutional sense, by issuing revenue bonds on the security of anticipated toll revenues. By adopting this course the amount to be paid by tolls is cut in half, the bridge can be freed in half the time that would otherwise be required for the payment of its cost, and the public can be assured that it is paying no unnecessary amount of profit to private capitalists.

There is an active market for toll-bridge bonds, and the public can sell on terms that are usually more favorable than those available to private builders. The existing public agencies can erect and operate the bridges as efficiently and economically as private builders. Under public auspices there is assurance of open competition by qualified contracting organizations for the construction of the bridge and the further assurance that the contract will be awarded to the lowest responsible bidder, conditions that have been noticeably lacking in much of the private construction upon which the public has been asked to pay dividends in the form of tolls.

In consideration of these and other facts of similar purport, which it has established by study and investigation, the bureau generally opposes the construction of private toll bridges and favors construction under public auspices whether or not it be necessary to resort to tolls as a measure of finance. It has recommended against the granting of authority to private interests in numerous cases, when congressional bills have been submitted for its consideration; but in many cases its recommendation has not been followed. The facts in its possession were placed before the Congress at the last session; and it is hoped that a careful consideration of these facts will lead that body to extend the legislative support needed and earnestly desired by the highway administrative authorities of the Government and the States in dealing with this difficult problem of major bridge construction.

STANDARD SIGNS AND WAYSIDE PLANTING

By amendment of the law, Federal appropriations may now be expended to aid the States in the erection of the standard numeral markers and direction and danger signs adopted for the United States highway system, on all parts of that system that are also included in the Federal-aid system. This permission extends to nearly the entire mileage of the United States system, and during the past year a number of the States have taken advantage of the proffered aid.

The erection of these signs on the principal transcontinental highways has contributed immeasurably to the convenience and safety of travel. The signs are well designed and easily understood. They have quickly become familiar to the traveling public, and their erection is uniformly indorsed by road users.

The complete effectiveness of these signs erected at public expense for the greater convenience and safety of travelers is hindered in some instances by advertising signboards so placed as to obscure them or withdraw attention from them. In many cases such advertisements contain misleading information, with regard to intermediate distances on the highway and the condition of the road ahead, which is belied in less obtrusive fashion by the public signs. To the extent that they obscure, or contradict, or divert attention from the proper road signs, these signboards are a positive hindrance and menace to the traveling public.

Designedly placed where they will receive the utmost attention, they frequently obscure or mar attractive roadside views and so detract from the pleasurable use of the highways. Accustomed as we are to their unwanted presence in ordinary surroundings, to come upon these blatant commercial appeals high on the face of a majestic cliff, marring a mountainside, or completely obscuring a particularly beautiful vista still awakens a sense of their utter incongruity.

In practically all cases these roadside advertisements merely repeat in the same form appeals that are made quite properly and insistently through other agencies. They are unneeded by the public and of doubtful value to the advertisers. Their disfigurement of the landscape is a national disgrace. It is hoped that means may be found by suitable legislation to effect their complete elimination upon all roads constructed in part with money appropriated by the National Government.

The recent amendment of the Federal highway act which permits payment by the Federal Government of part of the cost of wayside planting is timely. The States of California, Connecticut, and Massachusetts, and others have already demonstrated how much can be done at small cost to beautify the roadsides by judicious planting of native trees, shrubs, and perennial flowers. With the cooperation of forestry and horticultural authorities of the States and Federal Government and the support of civic bodies and property owners similar attractive results can be quickly and cheaply obtained in other States.

The public acquisition of suitable tracts of land at intervals along the highways, and the development of such tracts as State parks for purposes of recreation and the conservation of timber and animal life; where feasible, the acquisition of small, road-bordering strips and plots for development as parkways and parkets; these ideas should appeal not only to those who have at heart the enhancement of the appearance of the roadsides but also to all persons interested in conservation and larger facilities for outdoor recreation.

THE IMPORTANCE OF PLANNING FOR THE FUTURE

The studies of the flow and growth of highway traffic made by the bureau in recent years have emphasized the fundamental importance of careful present consideration of future needs in reestablishing the location and planning the structure of our highways.

Taking the country as a whole, traffic on the roads has doubled in less than five years' time, and in some States it is still increasing at an even more rapid rate.

The design of motor vehicles has been so perfected that speed considerably in excess of former possibilities can be attained without increase of hazard so far as the vehicles themselves are concerned.

The remarkable developments that have recently occurred in the design and use of common-carrier busses are probably no more than the beginning of a much further development that is to occur in this form of conveyance.

Traffic congestion, until recently a serious problem only in the cities, has moved outward and now imposes its time-consuming delays and menace to life and property upon the principal highways in the vicinity of the large metropolitan centers.

These facts must be taken into account in the planning of future Federal-aid improvements. They point especially to the necessity of acquiring rights of way of ample width to allow for future widening or the making of definite provision for future acquisition as needed; to the importance of designing the highways for safe use at higher speeds; to the desirability of considering the improvement of arterial route with the service of the entire route in mind; and, in metropolitan areas, to the urgency of grade-crossing elimination, wider pavements, and the building of relief and by-pass highways.

FEDERAL FUNDS APPORTIONED AND OBLIGATED

For the fiscal year 1928, the Federal-aid appropriation authorized by Congress was $75,000,000. This sum, less 2½ per cent deducted for Federal administration and highway research, was apportioned among the several States and the Territory of Hawaii on December 31, 1926. The total amount apportioned was $73,125,000, and the amounts credited to each State are shown in Table 19.

Although the fiscal year for which the funds were authorized did not begin until July 1, 1927, the law provides that agreements for the expenditure of the money on definite projects may be entered into between the State and Federal authorities as soon as the apportionment has been made, and these agreements become binding obligations of the Federal Government.

On June 30, 1927, at the beginning of the fiscal year, the unobligated balance of all funds apportioned including the apportionment for the fiscal year 1928, was $69,440,955, or nearly $3,000,000 less than the apportionment for the year.

This balance was available for obligation under agreements negotiated subsequent to the beginning of the fiscal year. On December 1, 1927, the amount available was again increased

by $73,125,000, the amount apportioned of the funds authorized for the fiscal year 1929. On June 30, 1928, the unobligated balance of all available funds—including those for the fiscal year 1929—was $53,643,770. In other words, there had already been obligated, before the beginning of the new fiscal year, nearly $20,000,000 of the $73,125,000 authorized for that year. This is in accordance with the provision of the law which directs the Secretary of Agriculture to apportion the authorized appropriations six months before the beginning of the fiscal year for which they are authorized and authorizes him to incur obligations thereunder immediately.

It is apparent from the above that the sums obligated during the fiscal years 1927 and 1928 exceeded the sums authorized and apportioned for those years, and reference to Table 6 will show that this condition has existed since the fiscal year 1923.

TABLE 6.—*Federal-aid funds apportioned to the States and obligated by them for the fiscal years 1923 to 1928, inclusive*

Fiscal year	Apportioned amount of appropriation authorized for the year	Amount of Federal-aid funds obligated during the year
1923	$48,750,000	$77,461,559
1924	63,375,000	89,866,864
1925	73,125,000	87,294,396
1926	73,125,000	79,608,897
1927	73,125,000	77,453,046
1928	73,125,000	88,922,185
Total	404,625,000	500,606,947
Average	67,437,500	83,434,491

For the 6 year period (1923 to 1928, inclusive) the average amount obligated annually was $83,434,491 (Table 6), and the average sum apportioned was $67,437,500. At the close of each year of this period the unobligated balance has been smaller than at the close of the previous year, and at present the balance available of all funds thus far apportioned, including those for the ensuing fiscal year (1929), is less by nearly $20,000,000 than the authorized appropriation for the latter year.

It is apparent from the foregoing analysis that for several years the Federal-aid road program has exceeded the amount of appropriations currently authorized. Prior to the fiscal year 1927 the excess of obligations over authorizations served to reduce the accumulated unobligated balance of earlier authorizations. In that year the accumulated balance was wiped out, and the accustomed rate of obligation has been maintained only by heavy obligation of funds authorized for the succeeding year in the six months between the date of their apportionment and the beginning of the new fiscal year. Obviously this practice is self-terminating, and it will be necessary eventually either to reduce the annual program or increase the appropriations annually authorized.

COST OF THE ROADS

The total cost of the 8,184 miles of initial construction and the 2,014 miles of stage construction completed during the year was $205,043,784, of which the Federal Government paid $88,056,984, or 43 per cent, and the States the balance. These expenditures were made over the period required to construct the roads brought to completion during the year, which was approximately two years. During the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal-aid funds during the year was $80,802,232.55, as shown in Table 19. This expenditure was about a half million dollars less than the expenditure of the previous year.

The largest disbursements during the year were made to Illinois, Iowa, Kansas, New York, Pennsylvania, and Texas. To each of these States the Federal Government paid during the year more than $3,000,000. All other States received less than that amount.

SUMMARY OF FEDERAL-AID ROAD WORK, BY STATES

The progress made in each of the States during the year and the results of the 12 years of Federal-aid road construction are set forth in the following condensed summary for each State.

ALABAMA

The Federal-aid highway system includes 3,884 miles, of which 1,748 miles have been improved with Federal aid. Of the improved mileage, 310 miles were added during the year. At the close of the year 270.5 miles were under construction and 48.7 miles were approved.

The mileage improved with Federal aid consists of 65.7 miles of graded and drained earth roads, 524.7 miles of sand-clay, 886.8 miles of gravel, 11.6 miles of water-bound macadam, 74.1 miles of bituminous macadam, 87.5 miles of bituminous concrete, and 91.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 5.8 miles.

The total cost of all Federal-aid roads completed during the year, including 1.9 miles of stage construction, was $4,495,050.49 of which the Federal share was $2,178,119.49. The disbursement of Federal funds to the State was $2,759,986.85. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,645,844.81.

ARIZONA

The Federal-aid highway system includes 1,498 miles, of which 851.4 miles have been improved with Federal aid. Of the improved mileage, 16.1 miles were added during the year. At the close of the year 86 miles were under construction.

The mileage improved with Federal aid consists of 124.7 miles of graded and drained earth roads, 115.8 miles of sand-clay, 458.2 miles of gravel, 14.2 miles of water-bound macadam, 26.6 miles of bituminous concrete, and 108.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3 miles.

The total cost of all Federal-aid roads completed during the year was $655,349.80 of which the Federal share was $467,215.24. The disbursement of Federal funds to the State was $422,436.01. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $2,896,024.65.

ARKANSAS

The Federal-aid highway system includes 5,021.1 miles, of which 1,678.2 miles have been improved with Federal aid. Of the improved mileage, 90.7 miles were added during the year. At the close of the year 180.7 miles were under construction and 9.9 miles were approved.

The mileage improved with Federal aid consists of 11.3 miles of graded and drained earth roads, 3 miles of sand-clay, 1,122.3 miles of gravel, 48.3 miles of water-bound macadam, 112.2 miles of bituminous macadam, 256.3 miles of bituminous concrete, and 120.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.9 miles.

The total cost of all Federal aid roads completed during the year was $954,845.03, of which the Federal share was $445,342.40. The disbursement of Federal funds to the State was $796,612.86. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,766,771.75.

CALIFORNIA

The Federal-aid highway system includes 4,771.5 miles, of which 1,455.6 miles have been improved with Federal aid. Of the improved mileage, 98.5 miles were added during the year. At the close of the year 120.7 miles were under construction and 43.7 miles were approved.

The mileage improved with Federal aid consists of 315.8 miles of graded and drained earth roads, 357 miles of gravel, 18.7 miles of water-bound macadam, 63.7 miles of bituminous macadam 141.6 miles of bituminous concrete, 553 miles of Portland cement concrete, in addition to which there are bridges with a total length of 5.8 miles.

The total cost all Federal-aid roads completed during the year was $4,395,894.90, of which the Federal share was $1,771,379.44. The disbursement of Federal funds to the State was $2,444,944.39. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $3,363,012.39.

COLORADO

The Federal-aid highway system includes 3,332 miles, of which 979.3 miles have been improved with Federal aid. Of the improved mileage, 24.9 miles were added during the year. At the close of the year 189.4 miles were under construction and 12.7 miles were approved.

The mileage improved with Federal aid consists of 226.2 miles of graded and drained earth roads, 96.2 miles of sand-clay, 426.5 miles of gravel, 4 miles of bituminous concrete, and 219.4 miles of Portland cement concrete, in addition to which there are bridges with a total length of 7 miles.

The total cost of all Federal-aid roads completed during the year, including 3.2 miles of stage construction, was $905,351.91 of which the Federal share was $455,668.30. The disburse-

ment of Federal funds to the State was $1,371,058.74. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $2,573,202.04.

CONNECTICUT

The Federal-aid highway system includes 835.4 miles, of which 206.5 miles have been improved with Federal aid. Of the improved mileage, 55.5 miles were added during the year. At the close of the year 34.4 miles were under construction and 3.6 miles were approved.

The mileage improved with Federal aid consists of 0.2 mile of gravel, 17.4 miles of water-bound macadam, 27 miles of bituminous macadam, 0.6 mile of bituminous concrete, and 158.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed during the year was $3,906,025.81 of which the Federal share was $1,124,080.50. The disbursement of Federal funds to the State was $415,289.33. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $566,752.61.

DELAWARE

The Federal-aid highway system includes 431.5 miles, of which 195.7 miles have been improved with Federal aid. Of the improved mileage, 35 miles were added during the year. At the close of the year 5.7 miles were under construction and 12.9 miles were approved.

The mileage improved with Federal aid consists of 5 miles of water-bound macadam, 7 miles of bituminous macadam, 13.7 miles of bituminous concrete, 167.2 miles of Portland cement concrete, and 2.3 miles of brick, in addition to which there are bridges with a total length of 0.5 mile.

The total cost of all Federal-aid roads completed during the year was $808,932.97, of which the Federal share was $361,314.04. The disbursement of Federal funds to the State was $396,176.60. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $190,680.44.

FLORIDA

The Federal-aid highway system includes 1,926 miles, of which 385.8 miles have been improved with Federal aid. Of the improved mileage, 75.6 miles were added during the year. At the close of the year 99.7 miles were under construction and 30.7 miles were approved.

The mileage improved with Federal aid consists of 9 miles of graded and drained earth roads, 15.7 miles of sand-clay, 69.8 miles of gravel, 29.8 miles of water-bound macadam, 78.9 miles of bituminous macadam, 42 miles of bituminous concrete, 123.4 miles of Portland cement concrete, and 10.1 miles of brick, in addition to which there are bridges with a total length of 7.1 miles.

The total cost of all Federal-aid roads completed during the year was $3,497,582.47, of which the Federal share was $1,556,930.83. The disbursement of Federal funds to the State was $1,261,265.91. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,210,489.75.

GEORGIA

The Federal-aid highway system includes 5,576.7 miles, of which 2,457.5 miles have been improved with Federal aid. Of the improved mileage, 118.2 miles were added during the year. At the close of the year 168.2 miles were under construction and 102.3 miles were approved.

The mileage improved with Federal aid consists of 210.5 miles of graded and drained earth roads, 1,173.4 miles of sand-clay, 413.6 miles of gravel, 86.9 miles of water-bound macadam, 134.3 miles of bituminous macadam, 26.8 miles of bituminous concrete, 384.4 miles of Portland cement concrete, and 0.5 mile of brick, in addition to which there are bridges with a total length of 27.1 miles.

The total cost of all Federal-aid roads completed during the year, including 90.9 miles of stage construction, was $4,846,753.53, of which the Federal share was $2,227,438.42. The disbursement of Federal funds to the State was $2,260,205.94. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $17,567.82.

IDAHO

The Federal-aid highway system includes 2,770 miles, of which 937.1 miles have been improved with Federal aid. Of the improved mileage, 43.5 miles were added during the year. At the close of the year 116.5 miles were under

construction and 101.6 miles were approved.

The mileage improved with Federal aid consists of 185.2 miles of graded and drained earth roads, 13.9 miles of sand-clay, 592 miles of gravel, 22.5 miles of water-bound macadam, 4 9 miles of bituminous macadam, 79.3 miles of bituminous concrete, and 36.3 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3 miles.

The total cost of all Federal-aid roads completed during the year, including 32 2 miles of stage construction, was $1,187,587.69 of which the Federal share was $729,934.10. The disbursement of Federal funds to the State was $936,021.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $138 890.41.

ILLINOIS

The Federal-aid highway system includes 6.618.5 miles, of which 1,685.4 miles have been improved with Federal aid. Of the improved mileage, 142.2 miles were added during the year. At the close of the year 620.1 miles were under construction and 148 miles were approved.

The mileage improved with Federal aid consists of 110.3 miles of graded and drained earth roads, 0.4 mile of gravel, 3 4 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1,536 miles of Portland cement concrete, and 25.8 miles of brick, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed during the year was $3.918.735.90, of which the Federal share was $1.901,874.76. The disbursement of Federal funds to the State was $3.021,486.88. The unobligated balance available on June 30. 1928, of all appropriations authorized and apportioned up to that date was $114,597.22

INDIANA

The Federal-aid highway system includes 4,701.5 miles, of which 1,060.1 miles have been improved with Federal aid. Of the improved mileage, 222.1 miles were added during the year. At the close of the year 314.2 miles were under construction and 61.3 miles were approved.

The mileage improved with Federal aid consists of 13.5 miles of graded and drained earth roads, 42.2 miles of gravel, 41.6 miles of water-bound macadam, 23.4 miles of bituminous macadam, 12 miles of bituminous concrete, 917.2 miles of Portland cement concrete, and 6.6 miles of brick, in addition to which there are bridges with a total length of 3.6 miles.

The total cost of all Federal-aid roads completed during the year, was $6,007,355.89 of which the Federal share was $2,915,222.26. The disbursement of Federal funds to the State was $2,767,823.43. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $267,083 14.

IOWA

The Federal-aid highway system includes 7,212 miles, of which 2,831.5 miles have been improved with Federal aid. Of the improved mileage, 378.8 miles were added during the year. At the close of the year 145.2 miles were under construction and 10.2 miles were approved.

The mileage improved with Federal aid consists of 1,455.6 miles of graded and drained earth roads, 566 2 miles of gravel, 786 miles of Portland cement concrete, and 22 miles of brick, in addition to which there are bridges with a total length of 1.7 miles.

The total cost of all Federal-aid roads completed during the year, including 84.7 miles of stage construction, was $8,915,667.75, of which the Federal share was $4,115,257.62. The disbursement of Federal funds to the State was $3,507,729.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $171,307.77.

KANSAS

The Federal-aid highway system includes 7,925 miles, of which 2.202.4 miles have been improved with Federal aid. Of the improved mileage, 578.3 miles were added during the year. At the close of the year 242.8 miles were under construction and 106.3 miles were approved.

The mileage improved with Federal aid consists of 877.3 miles of graded and drained earth roads, 217.1 miles of sand-clay, 229.8 miles of gravel, 4.5 miles of water-bound macadam, 113.9 miles of bituminous macadam, 3.5 miles of bituminous concrete, 590 miles of Portland cement concrete, and 153.9 miles of brick, in addition to which there are bridges with a total length of 12.4 miles.

The total cost of all Federal-aid roads completed during the year, in-

cluding 18 miles of stage construction, was $9,592,174.56, of which the Federal share was $4,023,845.38. The disbursement of Federal funds to the State was $3,071,637.66. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,284,552.84.

KENTUCKY

The Federal-aid highway system includes 3,702.5 miles, of which 1,148.9 miles have been improved with Federal aid. Of the improved mileage, 250.9 miles were added during the year. At the close of the year 227.4 miles were under construction and 62.7 miles were approved.

The mileage improved with Federal aid consists of 522 miles of graded and drained earth roads, 246.1 miles of gravel, 41.3 miles of water-bound macadam, 182.2 miles of bituminous macadam, 1 mile of bituminous concrete, 150.2 miles of Portland cement concrete, and 3.9 miles of brick, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year, including 30.7 miles of stage construction, was $5,421,784.29, of which the Federal share was $2,361,246.84. The disbursement of Federal funds to the State was $2,214,946.66. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $529,296.09.

LOUISIANA

The Federal-aid highway system includes 2,712.9 miles, of which 1,276 miles have been improved with Federal aid. Of the improved mileage, 61.5 miles were added during the year. At the close of the year 193 miles were under construction and 8.8 miles were approved.

The mileage improved with Federal aid consists of 25.6 miles of graded and drained earth roads, 1,173.3 miles of gravel, 3.2 miles of water-bound macadam, 9.5 miles of bituminous macadam, 33.5 miles of bituminous concrete, and 22.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 8.1 miles.

The total cost of all Federal-aid roads completed during the year, including 7.5 miles of stage construction, was $2,647,414.58, of which the Federal share was $1,086,023.19. The disbursement of Federal funds to the State was $959,664.41. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $317,573.20.

MAINE

The Federal-aid highway system includes 1,428.9 miles, of which 428.7 miles have been improved with Federal aid. Of the improved mileage, 65.8 miles were added during the year. At the close of the year 39.7 miles were under construction and 14.2 miles were approved.

The mileage improved with Federal aid consists of 192 miles of gravel, 157.2 miles of bituminous macadam, and 79.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.4 mile.

The total cost of all Federal-aid roads completed during the year was $2,319,089.55, of which the Federal share was $808,501.50. The disbursement of Federal funds to the State was $469,884.26. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,380,996.50.

MARYLAND

The Federal-aid highway system includes 1,527.7 miles, of which 557.5 miles have been improved with Federal aid. Of the improved mileage, 75.6 miles were added during the year. At the close of the year 30 miles were under construction and 38.6 miles were approved.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of gravel, 0.2 mile of water-bound macadam, 200.1 miles of bituminous macadam, 17 miles of bituminous concrete, and 304 miles of Portland cement concrete.

The total cost of all Federal-aid roads completed during the year was $1,481,188.35, of which the Federal share was $696,177.50. The disbursement of Federal funds to the State was $555,946.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $143,816.23.

MASSACHUSETTS

The Federal-aid highway system includes 1,308 miles, of which 501.1 miles have been improved with Federal aid. Of the improved mileage, 60.5 miles

were added during the year. At the close of the year 71.4 miles were under construction and 5.6 miles were approved.

The mileage improved with Federal aid consists of 0.4 mile of gravel, 3.5 miles of water-bound macadam, 259.2 miles of bituminous macadam, 50.5 miles of bituminous concrete, and 183.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 4.4 miles.

The total cost of all Federal-aid roads completed during the year was $2,957,259.58, of which the Federal share was $957,873.69. The disbursement of Federal funds to the State was $676,811.29. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $2,151,418.10.

MICHIGAN

The Federal-aid highway system includes 5,243 miles, of which 1,337.3 miles have been improved with Federal aid. Of the improved mileage, 175.8 miles were added during the year. At the close of the year 328.5 miles were under construction and 29.4 miles were approved.

The mileage improved with Federal aid consists of 10.4 miles of graded and drained earth roads, 364.5 miles of gravel, 18.9 miles of water-bound macadam, 10.4 miles of bituminous macadam, 73.4 miles of bituminous concrete, 857.7 miles of Portland cement concrete, and 0.4 mile of brick, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of all Federal-aid roads completed during the year was $5,431,692.50, of which the Federal share was $2,369,018.36. The disbursement of Federal funds to the State was $2,326,490.95. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $627,344.95.

MINNESOTA

The Federal-aid highway system includes 6,849.6 miles, of which 3,823.8 miles have been improved with Federal aid. Of the improved mileage, 248.7 miles were added during the year At the close of the year 305.9 miles were under construction and 49.8 miles were approved.

The mileage improved with Federal aid consists of 656.4 miles of graded and drained earth roads, 6.2 miles of sand-clay, 2,522.3 miles of gravel, 32.7 miles of bituminous concrete, and 605.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.7 mile.

The total cost of all Federal-aid roads completed during the year, including 110.3 miles of stage construction, was $5,852,424.86 of which the Federal share was $2,001,398.90. The disbursement of Federal funds to the State was $1,986,635.11. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $398,471.43

MISSISSIPPI

The Federal-aid highway system includes 3,604 miles, of which 1,533.6 miles have been improved with Federal aid. Of the improved mileage 187.8 miles were added during the year. At the close of the year 228.3 miles were under construction and 11.5 miles were approved.

The mileage improved with Federal aid consists of 212.4 miles of graded and drained earth roads, 16.6 miles of sand-clay, 1,081.5 miles of gravel, 11.1 miles of water-bound macadam, 1 mile of bituminous macadam, 9.5 miles of bituminous concrete, 186.1 miles of Portland cement concrete, and 9.7 miles of brick, in addition to which there are bridges with a total length of 5.7 miles.

The total cost of all Federal-aid roads completed during the year, including 36 miles of stage construction, was $4,633,642, of which the Federal share was $2,246,390.87. The disbursement of Federal funds to the State was $1,839,908.75. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $892,222.08.

MISSOURI

The Federal-aid highway system includes 7,530 miles, of which 2,210.1 miles have been improved with Federal aid. Of the improved mileage, 171.7 miles were added during the year. At the close of the year 132.8 miles were under construction and 46.3 miles were approved.

The mileage improved with Federal aid consists of 375.3 miles of graded and drained earth roads, 844.7 miles of gravel, 7.4 miles of water-bound macadam, 50.8 miles of bituminous macadam, 17.7 miles of bituminous concrete, 884.1 miles of Portland cement concrete, and 20.9 miles of brick, in addition to which there are bridges with a total length of 9.2 miles.

The total cost of all Federal-aid roads completed during the year, including 22.1 miles of stage construction, was $4,004,271.51, of which the Federal share was $2,099,546.14. The disbursement of Federal funds to the State was $2,658,532.48. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,550,939.55.

MONTANA

The Federal-aid highway system includes 4,673.5 miles, of which 1,299.3 miles have been improved with Federal aid. Of the improved mileage, 142.1 miles were added during the year. At the close of the year 275.6 miles were under construction and 235.1 miles were approved.

The mileage improved with Federal aid consists of 219.5 miles of graded and drained earth roads, 5.6 miles of sand-clay, 1,011 miles of gravel, 17.8 miles of water-bound macadam, 6.9 miles of bituminous macadam, 2.8 miles of bituminous concrete, and 31.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.8 miles.

The total cost of all Federal-aid roads completed during the year, including 9.2 miles of stage construction, was $1,734,065.14, of which the Federal share was $1,133,573.73. The disbursement of Federal funds to the State was $1,778,896.60. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $4,353,988.31.

NEBRASKA

The Federal-aid highway system includes 5,578.9 miles, of which 3,032.3 miles have been improved with Federal aid. Of the improved mileage, 589.1 miles were added during the year. At the close of the year 644.1 miles were under construction.

The mileage improved with Federal aid consists of 476.8 miles of graded and drained earth roads, 1,612.5 miles of sand-clay, 828.5 miles of gravel, 13.8 miles of bituminous concrete, 74.6 miles of Portland cement concrete, and 19.6 miles of brick, in addition to which there are bridges with a total length of 6.5 miles.

The total cost of all Federal-aid roads completed during the year, including 387.8 miles of stage construction, was $5,960,353.53, of which the Federal share was $2,781,546.22. The disbursement of Federal funds to the State was $2,653,649.87. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,999,143.13.

NEVADA

The Federal-aid highway system includes 1,513 miles, of which 1,018.6 miles have been improved with Federal aid. Of the improved mileage, 106.2 miles were added during the year. At the close of the year 137.3 miles were under construction.

The mileage improved with Federal aid consists of 51.4 miles of graded and drained earth roads, 14 miles of sand-clay, 854.3 miles of gravel, 28.8 miles of water-bound macadam, 20.6 miles of bituminous macadam, 2 miles of bituminous concrete, and 44.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.6 miles.

The total cost of all Federal-aid roads completed during the year, including 27.4 miles of stage construction, was $1,052,032.79, of which the Federal share was $908,656.42. The disbursement of Federal funds to the State was $937,054.96. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $595,556.89.

NEW HAMPSHIRE

The Federal-aid highway system includes 980.9 miles, of which 305.6 miles have been improved with Federal aid. Of the improved mileage, 37.1 miles were added during the year. At the close of the year 19 miles were under construction and 9.2 miles were approved.

The mileage improved with Federal aid consists of 99.2 miles of gravel, 66.2 miles of water-bound macadam, 88.6 miles of bituminous macadam, 32.9 miles of bituminous concrete, and 13.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 5 miles.

The total cost of all Federal-aid roads completed during the year, was $1,208,093.27, of which the Federal share was $544,659.08. The disbursement of Federal funds to the State was $371,194.25. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $65,727.25.

NEW JERSEY

The Federal-aid highway system includes 1,181.7 miles, of which 418.3 miles have been improved with Federal aid. Of the improved mileage, 73.2 miles were added during the year. At the close of the year 71.3 miles were under construction.

The mileage improved with Federal aid consists of 8.9 miles of graded and drained earth roads, 4.7 miles of gravel, 21.9 miles of bituminous concrete, and 380.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year, was $3,947,540.98, of which the Federal share was $1,104,039.78. The disbursement of Federal funds to the State was $1,319,535. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $253,177.

NEW MEXICO

The Federal-aid highway system includes 3,298 miles, of which 1,740.3 miles have been improved with Federal aid. Of the improved mileage, 180.1 miles were added during the year. At the close of the year 155.2 miles were under construction and 56.1 miles were approved.

The mileage improved with Federal aid consists of 244.2 miles of graded and drained earth roads, 5.1 miles of sand-clay, 1,416.6 miles of gravel, 0.7 mile of bituminous concrete, and 70.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of all Federal-aid roads completed during the year was $2,527,839.60, of which the Federal share was $1,957,717.94. The disbursement of Federal funds to the State was $1,417,762.65. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $894,813.28.

NEW YORK

The Federal-aid highway system includes 5,451 miles, of which 1,864.8 miles have been improved with Federal aid. Of the improved mileage, 385 miles were added during the year. At the close of the year 460.6 miles were under construction and 116.9 miles were approved.

The mileage improved with Federal aid consists of 12.9 miles of graded and drained earth roads, 4.6 miles of sand-clay, 46.5 miles of gravel, 358.3 miles of bituminous macadam, 12.6 miles of bituminous concrete, 1,427.5 miles of Portland cement concrete, and 0.7 mile of brick, in addition to which there are bridges with a total length of 1.7 miles.

The total cost of all Federal-aid roads completed during the year, was $19,211,852.17, of which the Federal share was $6,002,773.59. The disbursement of Federal funds to the State was $5,061,107.41. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $3,910,462.81.

NORTH CAROLINA

The Federal-aid highway system includes 3,959.9 miles, of which 1,582.4 miles have been improved with Federal aid. Of the improved mileage, 111 miles were added during the year. At the close of the year 89.7 miles were under construction and 5 miles were approved.

The mileage improved with Federal aid consists of 88.7 miles of graded and drained earth roads, 470 miles of sand-clay, 70.9 miles of gravel, 19.6 miles of water-bound macadam, 37.9 miles of bituminous macadam, 249.5 miles of bituminous concrete, and 643 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of all Federal-aid roads completed during the year, including 34.4 miles of stage construction, was $4,095,146.77, of which the Federal share was $1,894,205.65. The disbursement of Federal funds to the State was $1,589,297.53. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,141,531.23.

NORTH DAKOTA

The Federal-aid highway system includes 7,196 miles, of which 3,155.1 miles have been improved with Federal aid. Of the improved mileage, 469 miles were added during the year. At the close of the year 626.3 miles were under construction and 192.4 miles were approved.

The mileage improved with Federal aid consists of 1,259.6 miles of graded and drained earth roads, 21.1 miles of sand-clay, 1,855.5 miles of gravel, 5.3 miles of water-bound macadam, 1.9 miles of bituminous concrete, and 4.7

miles of Portland cement concrete, in addition to which there are bridges with a total length of 7 miles.

The total cost of all Federal-aid roads completed during the year, including 398.7 miles of stage construction, was $3,794,058.35, of which the Federal share was $2,030,873.31. The disbursement of Federal funds to the State was $1,409,404.82. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $637,992.37.

OHIO

The Federal-aid highway system includes 5,899.3 miles, of which 1,805.9 miles have been improved with Federal aid. Of the improved mileage, 261.4 miles were added during the year. At the close of the year 250.2 miles were under construction and 88.6 miles were approved.

The mileage improved with Federal aid consists of 65 miles of graded and drained earth roads, 6.7 miles of gravel, 135.1 miles of water-bound macadam, 367.9 miles of bituminous macadam, 93.9 miles of bituminous concrete, 669.7 miles of Portland cement concrete, and 465.5 miles of brick, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed during the year, including 4.2 miles of stage construction, was $8,417,081.38, of which the Federal share was $3,341,632.67. The disbursement of Federal funds to the State was $2,183,363.28. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $2,591,001.85.

OKLAHOMA

The Federal-aid highway system includes 5,528 miles, of which 1,589.7 miles have been improved with Federal aid. Of the improved mileage, 211.7 miles were added during the year. At the close of the year 171 miles were under construction and 109.7 miles were approved.

The mileage improved with Federal aid consists of 303.1 miles of graded and drained earth roads, 2.3 miles of sand-clay, 605.6 miles of gravel, 6.3 miles of water-bound macadam, 30.8 miles of bituminous macadam, 78.6 miles of bituminous concrete, 542.6 miles of Portland cement concrete, and 8.9 miles of brick, in addition to which there are bridges with a total length of 11.5 miles.

The total cost of all Federal-aid roads completed during the year, including 32.3 miles of stage construction, was $4,307,195.17, of which the Federal share was $1,834,190.38. The disbursement of Federal funds to the State was $1,618,293.19. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $387,602.49.

OREGON

The Federal-aid highway system includes 2,891.5 miles, of which 1,104.9 miles have been improved with Federal aid. Of the improved mileage 49.6 miles were added during the year. At the close of the year 40.7 miles were under construction and 6.7 miles were approved.

The mileage improved with Federal aid consists of 138.7 miles of graded and drained earth roads, 784.2 miles of gravel, 25.6 miles of water-bound macadam, 0.7 mile of bituminous macadam, 52.9 miles of bituminous concrete, and 99.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.9 miles.

The total cost of all Federal-aid roads completed during the year, including 38.6 miles of stage construction, was $1,709,077.30, of which the Federal share was $848,239.18. The disbursement of Federal funds to the State was $658,467.98. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,267,098.47.

PENNSYLVANIA

The Federal-aid highway system includes 4,993.9 miles, of which 1,837 miles have been improved with Federal aid. Of the improved mileage, 197.7 miles were added during the year. At the close of the year 240.7 miles were under construction and 82.4 miles were approved.

The mileage improved with Federal aid consists of 104.2 miles of graded and drained earth roads, 18.4 miles of bituminous macadam, 101.2 miles of bituminous concrete, 1,586.2 miles of Portland cement concrete, and 26.4 miles of brick, in addition to which there are bridges with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed during the year, including 3 miles of stage construction, was $9,834,885.37, of which the Federal share was $3,037,088.44. The dis-

bursement of Federal funds to the State was $3,031,621.22. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,850,129.27.

RHODE ISLAND

The Federal-aid highway system includes 362.4 miles, of which 136.2 miles have been improved with Federal aid. Of the improved mileage, 18 miles were added during the year. At the close of the year 26.8 miles were under construction and 4 miles were approved.

The mileage improved with Federal aid consists of 1.8 miles of waterbound macadam, 25.2 miles of bituminous macadam, 47.2 miles of bituminous concrete, and 61.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.1 mile.

The total cost of all Federal-aid roads completed during the year was $897,258.03, of which the Federal share was $280,149.31. The disbursement of Federal funds to the State was $318,506.03. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $576,046.16.

SOUTH CAROLINA

The Federal-aid highway system includes 3,230 miles, of which 1,631.6 miles have been improved with Federal aid. Of the improved mileage, 113.8 miles were added during the year. At the close of the year 205.5 miles were under construction and 10.4 miles were approved.

The mileage improved with Federal aid consists of 25.2 miles of graded and drained earth roads, 1,210.2 miles of sand-clay, 115.4 miles of gravel, 8.9 miles of water-bound macadam, 3 miles of bituminous macadam, 102.6 miles of bituminous concrete, 152.2 miles of Portland cement concrete, and 0.2 mile of brick, in addition to which there are bridges with a total length of 13.9 miles.

The total cost of all Federal-aid roads completed during the year, including 53.6 miles of stage construction, was $3,591,684.06, of which the Federal share was $1,182,549.75. The disbursement of Federal funds to the State was $1,259,902.48. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $64,396.43.

SOUTH DAKOTA

The Federal-aid highway system includes 5,902 miles, of which 2,834.4 miles have been improved with Federal aid. Of the improved mileage, 289.5 miles were added during the year. At the close of the year 584 miles were under construction and 107 miles were approved.

The mileage improved with Federal aid consists of 224.1 miles of graded and drained earth roads, 25.7 miles of sand-clay, 2,579.2 miles of gravel, and 2.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.7 miles.

The total cost of all Federal-aid roads completed during the year, including 193.2 miles of stage construction, was $2,039,746.84, of which the Federal share was $1,122,233.53. The disbursement of Federal funds to the State was $1,167,023.73. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $514,514.16.

TENNESSEE

The Federal-aid highway system includes 3,252.8 miles, of which 1,075.6 miles have been improved with Federal aid. Of the improved mileage, 100.3 miles were added during the year. At the close of the year 138.9 miles were under construction and 25.6 miles were approved.

The mileage improved with Federal aid consists of 157.1 miles of graded and drained earth roads, 123.8 miles of gravel, 52.2 miles of water-bound macadam, 428.8 miles of bituminous macadam, 33.5 miles of bituminous concrete, and 277.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.5 miles.

The total cost of all Federal-aid roads completed during the year, including 27.4 miles of stage construction, was $3,483,124.90, of which the Federal share was $1,496,826.48. The disbursement of Federal funds to the State was $1,157,624.72. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $254,777.15.

TEXAS

The Federal-aid highway system includes 11,690.9 miles of which 5,965.9 miles have been improved with Federal aid. Of the improved mileage, 433.2

miles were added during the year. At the close of the year 224.8 miles were under construction and 161.9 miles were approved.

The mileage improved with Federal aid consists of 705.4 miles of graded and drained earth roads, 90.5 miles of sand-clay, 2,986.8 miles of gravel, 508.4 miles of water-bound macadam, 870.3 miles of bituminous macadam, 137.2 miles of bituminous concrete, 627.6 miles of Portland cement concrete, and 29.1 miles of brick, in addition to which there are bridges with a total length of 10.6 miles.

The total cost of all Federal-aid roads completed, during the year, including 246.7 miles of stage construction, was $11,449,455.94, of which the Federal share was $5,344,336.60. The disbursement of Federal funds to the States was $4,367,659.10. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $3,975.468.70.

UTAH

The Federal-aid highway system includes 1,677.3 miles, of which 806.5 miles have been improved with Federal aid. Of the improved mileage, 97.6 miles were added during the year. At the close of the year 112.2 miles were under construction and 19.4 miles were approved.

The mileage improved with Federal aid consists of 94.7 miles of graded and drained earth roads, 41.7 miles of sand-clay, 548.9 miles of gravel, 16.8 miles of water-bound macadam, 0.7 mile of bituminous macadam, 9.9 miles of bituminous concrete, and 91.6 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year, including 7.5 miles of stage construction, was $1,546,236.97, of which the Federal share was $1,138,714.79. The disbursement of Federal funds to the State was $1,290,052.52. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $220,749.79.

VERMONT

The Federal-aid highway system includes 1,043 miles, of which 201.3 miles have been improved with Federal aid. Of the improved mileage, 40.9 miles were added during the year. At the close of the year 51.2 miles were under construction and 11.9 miles were approved.

The mileage improved with Federal aid consists of 96.4 miles of gravel, 8.2 miles of water-bound macadam, 45.6 miles of bituminous macadam, and 44.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 6.4 miles.

The total cost of all Federal-aid roads completed during the year was $1,826,258.67, of which the Federal share was $696,788.74. The disbursement of Federal funds to the State was $694,117.53. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $25,473.81.

VIRGINIA

The Federal-aid highway system includes 3,251.7 miles, of which 1,266.9 miles have been improved with Federal aid. Of the improved mileage, 105.6 miles were added during the year. At the close of the year 99 3 miles were under construction and 31.6 miles were approved.

The mileage improved with Federal aid consists of 55 miles of graded and drained earth roads, 192.5 miles of sand-clay, 119.9 miles of gravel, 112.3 miles of water-bound macadam, 306.6 miles of bituminous macadam, 10.6 miles of bituminous concrete, and 466.2 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.8 miles.

The total cost of all Federal-aid roads completed during the year, including 3.9 miles of stage construction, was $4,588,477.73, of which the Federal share was $1,893,029.67. The disbursement of Federal funds to the State was $1,439,060.08. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $237,-853.61.

WASHINGTON

The Federal-aid highway system includes 2,927.5 miles, of which 777.7 miles have been improved with Federal aid. Of the improved mileage, 73.6 miles were added during the year. At the close of the year 105.4 miles were under construction and 21.2 miles were approved.

The mileage improved with Federal aid consists of 145.7 miles of graded and drained earth roads, 344 miles of gravel, and 283.9 miles of Portland cement concrete, in addition to which

there are bridges with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year was $3,637,496.70, of which the Federal share was $1,649,901.70. The disbursement of Federal funds to the State was $521,599.31. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $481,843.46.

WEST VIRGINIA

The Federal-aid highway system includes 2,094.9 miles, of which 606.9 miles have been improved with Federal aid. Of the improved mileage, 132.9 miles were added during the year. At the close of the year 105.6 miles were under construction and 25.3 miles were approved.

The mileage improved with Federal aid consists of 227.4 miles of graded and drained earth roads, 3.9 miles of sand-clay, 19.9 miles of gravel, 4.9 miles of water-bound macadam, 159.7 miles of bituminous macadam, 28.2 miles of bituminous concrete, 150.2 miles of Portland cement concrete, and 11.4 miles of brick, in addition to which there are bridges with a total length of 1.3 miles.

The total cost of all Federal-aid roads completed during the year, including 4 miles of stage construction, was $3,778,799.97, of which the Federal share was $1,548,876.64. The disbursement of Federal funds to the State was $1,043,717. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $478,768.16.

WISCONSIN

The Federal-aid highway system includes 5,493.4 miles, of which 2,046.9 miles have been improved with Federal aid. Of the improved mileage, 323.7 miles were added during the year. At the close of the year 277.2 miles were under construction and 36.5 miles were approved.

The mileage improved with Federal aid consists of 208.6 miles of graded and drained earth roads, 104.4 miles of sand-clay, 1,042.2 miles of gravel, 6.8 miles of water-bound macadam, 13.7 miles of bituminous macadam, and 669.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed during the year, including 36.1 miles of stage construction, was $8,482,428.81, of which the Federal share was $3,983,658.48. The disbursement of Federal funds to the State was $2,959,014.72. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,435,440.82.

WYOMING

The Federal-aid highway system includes 3,097, of which 1,442.5 miles have been improved with Federal aid. Of the improved mileage, 124.5 miles were added during the year. At the close of the year 227 miles were under construction and 41.8 miles were approved.

The mileage improved with Federal aid consists of 383.2 miles of graded and drained earth roads, 484.2 miles of sand-clay, 516.8 miles of gravel, 15.5 miles of water-bound macadam, 22.1 miles of bituminous concrete, and 15.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 4.8 miles.

The total cost of all Federal-aid roads completed during the year, including 68.7 miles of stage construction, was $1,313,556.03, of which the Federal share was $849,085.28. The disbursement of Federal funds to the State was $1,106,907.83. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $167,116.50.

HAWAII

The Federal-aid highway system includes 174.6 miles of which 36.2 miles have been improved with Federal aid. Of the improved mileage 29.7 miles were added during the year. At the close of the year 3.2 miles were under construction and 1.8 miles were approved.

The mileage improved with Federal aid consists of 20.3 miles of bituminous macadam, and 15.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.1 mile.

The total cost of all Federal-aid roads completed during the year was $1,773,962.02, of which the Federal share was $551,836.79. The disbursement of Federal funds to the State was $325,901.59. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was $1,064,241.58.

FEDERAL-AID STATISTICS

Statistical information relative to the apportionment, obligation, and disbursement of Federal aid during the fiscal year 1928; the cost of roads completed and the estimated cost of roads under construction; and the type of roads completed and under construction, etc., is given in Tables 7 to 19, inclusive.

TABLE 7.—*Mileage of the designated Federal-aid highway system in each State and mileage improved with Federal aid to June 30, 1928*

State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1928
Alabama	3,884.0	1,748.0
Arizona	1,498.0	851.4
Arkansas	5,021.1	1,678.2
California	4,771.5	1,455.6
Colorado	3,332.0	979.3
Connecticut	835.4	206.5
Delaware	431.5	195.7
Florida	1,926.0	385.8
Georgia	5,576.7	2,457.5
Idaho	2,770.0	937.1
Illinois	6,618.5	1,685.4
Indiana	4,701.5	1,060.1
Iowa	7,212.0	2,831.5
Kansas	7,925.0	2,202.4
Kentucky	3,702.5	1,148.9
Louisiana	2,712.9	1,276.0
Maine	1,428.9	428.7
Maryland	1,527.7	557.5
Massachusetts	1,308.0	501.1
Michigan	5,243.0	1,337.3
Minnesota	6,849.6	3,823.8
Mississippi	3,604.0	1,533.6
Missouri	7,530.0	2,210.1
Montana	4,673.5	1,299.3
Nebraska	5,578.9	3,032.3
Nevada	1,513.0	1,018.6
New Hampshire	980.9	305.6
New Jersey	1,181.7	418.3
New Mexico	3,298.0	1,740.3
New York	5,451.0	1,864.8
North Carolina	3,959.9	1,582.4
North Dakota	7,196.0	3,155.1
Ohio	5,899.3	1,805.9
Oklahoma	5,528.0	1,589.7
Oregon	2,891.5	1,104.9
Pennsylvania	4,993.9	1,837.0
Rhode Island	362.4	136.2
South Carolina	3,230.0	1,631.6
South Dakota	5,902.0	2,834.4
Tennessee	3,252.8	1,075.6
Texas	11,690.9	5,965.9
Utah	1,677.3	806.5
Vermont	1,043.0	201.3
Virginia	3,251.7	1,266.9
Washington	2,927.5	777.7
West Virginia	2,094.9	606.9
Wisconsin	5,493.4	2,046.9
Wyoming	3,097.0	1,442.5
Hawaii	174.6	36.2
Total	187,752.9	71,074.3

TABLE 8.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1928*

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
Alabama	$4,495,050.49	$2,178,119.49	310.0	1.9	311.9
Arizona	655,349.80	467,215.24	16.1	----------	16.1
Arkansas	954,845.03	445,342.40	90.7	----------	90.7
California	4,395,894.90	1,771,379.44	98.5	----------	98.5
Colorado	905,351.91	455,668.30	24.9	3.2	28.1
Connecticut	3,906,025.81	1,124,080.50	55.5	----------	55.5
Delaware	808,932.97	361,314.04	35.0	----------	35.0
Florida	3,497,582.47	1,556,930.83	75.6	----------	75.6
Georgia	4,846,753.53	2,227,438.42	118.2	90.9	209.1
Idaho	1,187,587.69	729,934.10	43.5	32.2	75.7
Illinois	3,918,735.90	1,901,874.76	142.2	----------	142.2
Indiana	6,007,355.89	2,915,222.26	222.1	----------	222.1
Iowa	8,915,667.75	4,115,257.62	378.8	84.7	463.5
Kansas	9,592,174.56	4,023,845.38	578.3	18.0	596.3
Kentucky	5,421,784.29	2,361,246.84	250.9	30.7	281.6
Louisiana	2,647,414.58	1,086,023.19	61.5	7.5	69.0
Maine	2,319,089.55	808,501.50	65.8	----------	65.8
Maryland	1,481,188.35	696,177.50	75.6	----------	75.6
Massachusetts	2,957,259.58	957,873.69	60.5	----------	60.5
Michigan	5,431,692.50	2,369,018.36	175.8	----------	175.8
Minnesota	5,852,424.86	2,001,398.90	248.7	110.3	359.0
Mississippi	4,633,642.00	2,246,390.87	187.8	36.0	223.8
Missouri	4,004,271.51	2,099,546.14	171.7	22.1	193.8
Montana	1,734,065.14	1,133,573.73	142.1	9.2	151.3
Nebraska	5,960,353.53	2,781,546.22	589.1	387.8	976.9
Nevada	1,052,032.79	908,656.42	106.2	27.4	133.6
New Hampshire	1,208,093.27	544,659.08	37.1	----------	37.1

TABLE 8.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1928*—Continued

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
New Jersey	$3,947,540.98	$1,104,039.78	73.2		73.2
New Mexico	2,527,839.60	1,957,717.94	180.1		180.1
New York	19,211,852.17	6,002,773.59	385.0		385.0
North Carolina	4,095,146.77	1,894,205.65	111.0	34.4	145.4
North Dakota	3,794,058.35	2,030,873.31	469.0	398.7	867.7
Ohio	8,417,081.38	3,341,632.67	261.4	4.2	265.6
Oklahoma	4,307,195.17	1,834,190.38	211.7	32.3	244.0
Oregon	1,709,077.30	848,239.18	49.6	38.6	88.2
Pennsylvania	9,834,885.37	3,037,088.44	197.7	3.0	200.7
Rhode Island	897,258.03	280,149.31	18.0		18.0
South Carolina	3,591,684.06	1,182,549.75	113.8	53.6	167.4
South Dakota	2,039,746.84	1,122,233.53	289.5	193.2	482.7
Tennessee	3,483,124.90	1,496,826.48	100.3	27.4	127.7
Texas	11,449,455.94	5,344,336.60	433.2	246.7	679.9
Utah	1,546,236.97	1,138,714.79	97.6	7.5	105.1
Vermont	1,826,253.67	696,788.74	40.9		40.9
Virginia	4,588,477.73	1,893,029.67	105.6	3.9	109.5
Washington	3,637,496.70	1,649,901.70	73.6		73.6
West Virginia	3,778,799.97	1,548,876.64	132.9	4.0	136.9
Wisconsin	8,482,428.81	3,983,658.48	323.7	36.1	359.8
Wyoming	1,313,556.03	849,085.28	124.5	68.7	193.2
Hawaii	1,773,962.02	551,836.79	29.7		29.7
Total	205,043,784.41	88,056,983.92	8,184.2	2,014.2	10,198.4

TABLE 9.—*Total cost, Federal aid, and mileage of Federal-aid roads, initial and stage construction, under construction on June 30, 1928, by States*

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$5,195,635.95	$2,583,180.18	270.5	55.9	326.4
Arizona	1,795,361.35	1,577,922.94	86.0	.6	86.6
Arkansas	4,906,901.45	2,174,942.33	180.7		180.7
California	6,122,281.76	2,929,260.54	120.7	8.2	128.9
Colorado	5,134,698.11	2,627,641,63	189.4	9.2	198.6
Connecticut	3,269,777.06	831,098.01	34.4		34.4
Delaware	470,022.22	95,739 75	5.7	3.9	9.6
Florida	4,185,912.27	1,773,093.63	99.7	5.4	105.1
Georgia	3,701,359.50	1,805,098.52	168.2	30.7	198.9
Idaho	2,067,804.47	1,235,873.81	116.5	56.8	173.3
Illinois	19,966,945.33	9,204,790.58	620.1		620.1
Indiana	10,285,596.57	4,915,301.36	314.2	3.5	317.7
Iowa	7,006,259.73	2,993,700.52	145.2	137.3	282.5
Kansas	4,812,182.97	1,907,366.82	242.8		242.8
Kentucky	4,924,557.22	2,488,415.88	227.4		227.4
Louisiana	4,161,328.09	2,072,905.40	193.0		193.0
Maine	1,294,982.17	528,952.60	39.7		39.7
Maryland	738,690.77	353,730.00	30.0		30.0
Massachusetts	3,785,205.01	1,133,667.82	71.4		71.4
Michigan	13,340,940.37	5,616,223.08	328.5		328.5
Minnesota	6,287,137.06	2,088,100.00	305.9	54.7	360.6
Mississippi	4,361,785.79	2,149,654.95	228.3	30.9	259.2
Missouri	4,630,264.01	1,900,212.49	132.8	39.0	171.8
Montana	3,526,790.69	2,385,241.58	275.6	4.1	279.7
Nebraska	6,436,612.14	3,206,959.06	644.1	197.4	841.5
Nevada	1,156,011.48	1,012,597.47	137.3	28.4	165.7
New Hampshire	661,935.44	272,455.16	19.0		19.0
New Jersey	5,847,748.19	1,039,947.35	71.3		71.3
New Mexico	2,414,979.86	1,602,034.50	155.2		155.2
New York	30,549,500.00	7,164,693.95	460.6		460.6
North Carolina	2,052,044.50	981,951.81	89.7	13.0	102.7
North Dakota	3,660,655.06	1,740,332.78	626.3	165.4	791.7
Ohio	11,260,370.37	4,150,846.38	250.2	6.0	256.2
Oklahoma	3,367,788.78	1,617,074.66	171.0	6.4	177.4
Oregon	1,517,571.16	847,554.19	40.7		40.7
Pennsylvania	13,745,519.18	3,983,882.84	240.7		240.7
Rhode Island	1,723,452.42	431,049.92	26.8		26.8
South Carolina	8,499,229.16	1,887,138.22	205.5	120.7	326.2
South Dakota	3,458,251.40	1,855,200.66	584.0	73.3	657.3

TABLE 9.—*Total cost, Federal aid, and mileage of Federal-aid roads, initial and stage construction, under construction on June 30, 1928, by States*—Contd.

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Tennessee	$4,524,754.78	$1,939,405.06	138.9		138.9
Texas	8,914,648.60	3,494,782.06	224.8	125.1	349.9
Utah	1,996,561.57	1,364,094.82	112.2	12.3	124.5
Vermont	2,345,384.25	584,978.39	51.2		51.2
Virginia	4,221,703.93	1,337,952.75	99.3	21.6	120.9
Washington	4,144,458.77	1,437,000.00	105.4	18.1	123.5
West Virginia	2,789,397.94	1,244,328.22	105.6		105.6
Wisconsin	7,931,130.44	3,251,570.37	277.2	25.2	302.4
Wyoming	2,260,697.90	1,417,612.15	227.0	32.1	259.1
Hawaii	301,973.75	60,383.43	3.2		3.2
Total	261,754,800.99	105,297,930.62	9,493.9	1,285.2	10,779.1

TABLE 10.—*Total cost, Federal aid, and mileage of Federal-aid roads, initial and stage construction, approved for construction, as of June 30, 1928, by States*

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$717,945.71	$358,972.83	48.7	12.4	61.1
Arizona	122,094.33	42,024.80		4.2	4.2
Arkansas	250,474.26	102,414.55	9.9	6.2	16.1
California	1,573,168.56	703,031.15	43.7		43.7
Colorado	287,928.34	159,230.93	12.7	14.5	27.2
Connecticut	285,289.67	66,951.17	3.6		3.6
Delaware	310,591.60	155,295.80	12.9		12.9
Florida	905,396.31	333,505.44	30.7		30.7
Georgia	2,934,550.18	1,239,573.27	102.3	50.1	152.4
Idaho	1,100,504.72	653,836.57	101.6	1.8	103.4
Illinois	3,896,721.88	1,942,068.60	148.0		148.0
Indiana	1,671,729.13	807,135.04	61.3		61.3
Iowa	1,827,757.31	778,011.52	10.2	71.4	81.6
Kansas	1,348,337.76	598,232.45	106.3		106.3
Kentucky	1,159,696.00	579,848.00	62.7		62.7
Louisiana	724,325.88	239,803.83	8.8		8.8
Maine	586,603.30	200,682.36	14.2		14.2
Maryland	858,534.80	416,900.00	38.6	7.2	45.8
Massachusetts	361,296.54	84,345.00	5.6		5.6
Michigan	1,150,043.70	525,885.00	29.4	6.5	35.9
Minnesota	1,201,168.05	291,000.00	49.8	20.6	70.4
Mississippi	201,358.23	100,459.53	11.5	.6	12.1
Missouri	1,511,404.60	602,718.59	46.3	13.7	60.0
Montana	2,345,539.14	1,308,589.18	235.1	10.7	245.8
Nebraska	75,620.57	37,768.83		23.2	23.2
Nevada	59,079.34	51,419.58		23.7	23.7
New Hampshire	490,414.66	190,235.78	9.2		9.2
New Mexico	777,265.15	492,343.74	56.1	.5	56.6
New York	8,328,900.00	1,806,847.50	116.9	8.6	125.5
North Carolina	534,495.97	259,500.00	5.0	19.5	24.5
North Dakota	1,240,836.16	502,502.23	192.4	121.7	314.1
Ohio	4,757,780.00	1,340,636.26	88.6	6.7	95.3
Oklahoma	1,871,838.77	837,936.01	109.7	15.5	125.2
Oregon	278,334.10	146,673.72	6.7		6.7
Pennsylvania	4,414,639.79	1,318,026.22	82.4		82.4
Rhode Island	311,081.95	80,919.55	4.0		4.0
South Carolina	394,006.44	69,700.00	10.4	8.1	18.5
South Dakota	655,789.73	360,684.24	107.0	39.2	146.2
Tennessee	4,267,517.00	1,368,324.58	25.6	94.3	119.9
Texas	6,241,573.47	2,627,108.00	161.9	156.0	317.9
Utah	328,886.36	240,095.90	19.4	1.5	20.9
Vermont	584,323.08	147,454.36	11.9		11.9
Virginia	884,718.69	156,605.91	31.6		31.6
Washington	1,142,840.68	440,236.89	21.2	5.0	26.2
West Virginia	617,098.44	294,283.84	25.3		25.3
Wisconsin	1,400,034.42	433,988.43	36.5	15.7	52.2
Wyoming	296,051.33	190,064.91	41.8		41.8
Hawaii	175,931.99	57,501.20	1.8		1.8
Total	67,461,518.09	25,741,403.29	2,359.3	759.1	3,118.4

TABLE 11.—*Mileage of Federal-aid roads improved as of June 30, 1928, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous con-crete	Port-land cement concrete	Brick	Bridges	Total
Alabama	65.7	524.7	886.8	11.6	74.1	87.5	91.8	-------	5.8	1,748.0
Arizona	124.7	115.8	458.2	14.2	-------	26.6	108.9	-------	3.0	851.4
Arkansas	11.3	3.0	1,122.3	48.3	112.2	256.3	120.9	-------	3.9	1,678.2
California	315.8	-------	357.0	18.7	63.7	141.6	553.0	-------	5.8	1,455.6
Colorado	226.2	96.2	426.5	-------	-------	4.0	219.4	-------	7.0	979.3
Connecticut	-------	-------	.2	17.4	27.0	.6	158.9	-------	2.4	206.5
Delaware	-------	-------	-------	5.0	7.0	13.7	167.2	2.3	.5	195.7
Florida	9.0	15.7	69.8	29.8	78.9	42.0	123.4	10.1	7.1	385.8
Georgia	210.5	1,173.4	413.6	86.9	134.3	26.8	384.4	.5	27.1	2,457.5
Idaho	185.2	13.9	592.0	22.5	4.9	79.3	36.3	-------	3.0	937.1
Illinois	110.3	-------	.4	-------	3.4	8.1	1,536.0	25.8	1.4	1,685.4
Indiana	13.5	-------	42.2	41.6	23.4	12.0	917.2	6.6	3.6	1,060.1
Iowa	1,455.6	-------	566.2	-------	-------	-------	786.0	22.0	1.7	2,831.5
Kansas	877.3	217.1	229.8	4.5	113.9	3.5	590.0	153.9	12.4	2,202.4
Kentucky	522.0	-------	246.1	41.3	182.2	1.0	150.2	3.9	2.2	1,148.9
Louisiana	25.6	-------	1,173.3	3.2	9.5	33.5	22.8	-------	8.1	1,276.0
Maine	-------	-------	192.0	-------	157.2	-------	79.1	-------	.4	428.7
Maryland	4.7	-------	31.5	.2	200.1	17.0	304.0	-------	-------	557.5
Massachusetts	-------	-------	.4	3.5	259.2	50.5	183.1	-------	4.4	501.1
Michigan	10.4	-------	364.5	18.9	10.4	73.4	857.7	.4	1.6	1,337.3
Minnesota	656.4	6.2	2,522.3	-------	-------	32.7	605.5	-------	.7	3,823.8
Mississippi	212.4	16.6	1,081.5	11.1	1.0	9.5	186.1	9.7	5.7	1,533.6
Missouri	375.3	-------	844.7	7.4	50.8	17.7	884.1	20.9	9.2	2,210.1
Montana	219.5	5.6	1,011.0	17.8	6.9	2.8	31.9	-------	3.8	1,299.3
Nebraska	476.8	1,612.5	828.5	-------	-------	13.8	74.6	19.6	6.5	3,032.3
Nevada	51.4	14.0	854.3	28.8	20.6	2.0	44.9	-------	2.6	1,018.6
New Hampshire	-------	-------	99.2	66.2	88.6	32.9	13.7	-------	5.0	305.6
New Jersey	8.9	-------	4.7	-------	-------	21.9	380.5	-------	2.3	418.3
New Mexico	244.2	5.1	1,416.6	-------	-------	.7	70.9	-------	2.8	1,740.3
New York	12.9	4.6	46.5	-------	358.3	12.6	1,427.5	.7	1.7	1,864.8
North Carolina	88.7	470.0	70.9	19.6	37.9	249.5	643.0	-------	2.8	1,582.4
North Dakota	1,259.6	21.1	1,855.5	5.3	-------	1.9	4.7	-------	7.0	3,155.1
Ohio	65.0	-------	6.7	135.1	367.9	93.9	669.7	465.5	2.1	1,805.9
Oklahoma	303.1	2.3	605.6	6.3	30.8	78.6	542.6	8.9	11.5	1,589.7
Oregon	138.7	-------	784.2	25.6	.7	52.9	99.9	-------	2.9	1,104.9
Pennsylvania	104.2	-------	-------	-------	18.4	101.2	1,586.2	26.4	.6	1,837.0
Rhode Island	-------	-------	-------	1.8	25.2	47.2	61.9	-------	.1	136.2
South Carolina	25.2	1,210.2	115.4	8.9	3.0	102.6	152.2	.2	13.9	1,631.6
South Dakota	224.1	25.7	2,579.2	-------	-------	-------	2.7	-------	2.7	2,834.4
Tennessee	157.1	-------	123.8	52.2	428.8	33.5	277.7	-------	2.5	1,075.6
Texas	705.4	90.5	2,986.8	508.4	870.3	137.2	627.6	29.1	10.6	5,965.9
Utah	94.7	41.7	548.9	16.8	.7	9.9	91.6	-------	2.2	806.5
Vermont	-------	-------	96.4	8.2	45.6	-------	44.7	-------	6.4	201.3
Virginia	55.0	192.5	119.9	112.3	306.6	10.6	466.2	-------	3.8	1,266.9
Washington	145.7	-------	344.0	-------	-------	-------	283.9	-------	4.1	777.7
West Virginia	227.4	3.9	19.9	4.9	159.7	28.2	150.2	11.4	1.3	606.9
Wisconsin	208.6	104.4	1,042.2	6.8	13.7	-------	669.8	-------	1.4	2,046.9
Wyoming	383.2	484.2	516.8	15.5	-------	22.1	15.9	-------	4.8	1,442.5
Hawaii	-------	-------	-------	-------	20.3	-------	15.8	-------	.1	36.2
Total	10,611.3	6,470.9	27,698.3	1,426.6	4,317.2	1,993.3	17,516.3	817.9	222.5	71,074.3

TABLE 12.—*Mileage of Federal-aid roads initially completed during the fiscal year 1928, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Port-land cement concrete	Brick	Bridges	Total
Alabama	49.2	111.5	107.8		20.9		18.1		2.6	310.1
Arizona	4.7		10.6				.4		.4	16.1
Arkansas	11.3		62.9		13.3		2.7		.6	90.8
California	3.7		8.5	0.5	.5	61.4	23.1		.8	98.5
Colorado	−2.6	−9.5	24.3				11.7		1.0	24.9
Connecticut				8.7		.6	44.0		2.1	55.4
Delaware					7.0	13.7	14.1		.2	35.0
Florida	−.8		23.2	23.1	6.3	.1	19.5		4.1	75.5
Georgia	62.0	4.8	12.0	11.8	−.9	.9	24.8		2.7	118.1
Idaho	−10.4		49.8			2.7	.4		1.0	43.5
Illinois							142.2			142.2
Indiana			8.6	−15.1	6.4		214.9	6.6	.7	222.1
Iowa	190.9		19.7				167.7		.5	378.8
Kansas	340.1	70.9	31.7		16.2		102.2	14.1	3.2	578.4
Kentucky	141.5		58.9		24.6		24.3		1.6	250.9
Louisiana	.5		28.8			15.5	12.1		4.6	61.5
Maine			36.1		1.9		27.6		.1	65.7
Maryland					47.6		28.0			75.6
Massachusetts			.4		31.5	13.8	14.8			60.5
Michigan	10.0		34.6				130.3		.9	175.8
Minnesota	231.1		6.1				11.3		.2	248.7
Mississippi	60.4		91.1				30.9	.5	5.0	187.9
Missouri	56.5		5.5				109.7			171.7
Montana	15.6		122.7	1.9			.6		1.3	142.1
Nebraska	23.4	581.4	−38.7			2.9	18.4	.9	.7	589.0
Nevada			102.0	4.8					−.6	106.2
New Hampshire			.1	12.4	16.1	.2	5.9		2.4	37.1
New Jersey	2.8		.1				70.3			73.2
New Mexico	.8		177.4				.7		1.2	180.1
New York	10.5	4.6	23.8		13.3		332.6		.2	385.0
North Carolina							110.3		.7	111.0
North Dakota	349.7	10.8	107.5						1.0	469.0
Ohio	34.1			31.8	47.8		126.3	20.0	1.4	261.4
Oklahoma	122.0				9.9	−2.9	82.8			211.8
Oregon	32.0		17.4						.2	49.6
Pennsylvania	14.5				10.6		172.0		.6	197.7
Rhode Island					7.7		10.3			18.0
South Carolina	4.2	69.5	6.3			7.4	23.6		2.9	113.9
South Dakota	−12.6		300.0				1.5		.6	289.5
Tennessee	35.3		6.8		12.6	5.8	38.9		1.0	100.4
Texas	221.4		57.8		107.4	6.8	37.1		2.6	433.1
Utah	.5		96.7						.4	97.6
Vermont			−3.4	4.8	15.5		23.4		.6	40.9
Virginia				3.7	2.9		97.5		1.5	105.6
Washington	36.6		22.9				12.2		1.9	73.6
West Virginia	66.7				31.3	7.0	27.2		.7	132.9
Wisconsin			170.2	4.0			149.4			323.6
Wyoming	76.7		46.1				1.1		.6	124.5
Hawaii					13.8		15.8		.1	29.7
Total	2,182.3	844.0	1,836.3	92.4	464.2	135.9	2,532.7	42.1	54.3	8,184.2

TABLE 13.—*Mileage of Federal-aid roads under initial construction on June 30, 1928, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Port-land cement concrete	Brick	Bridges	Total
Alabama	146.0	18.4	72.6				31.2		2.3	270.5
Arizona	80.5		.3			3.0	.5		1.7	86.0
Arkansas	66.9		81.1		4.3		24.5		3.9	180.7
California	36.7		42.0	9.1	1.7	15.7	14.3		1.2	120.7
Colorado	32.4	16.5	82.5				55.9		2.1	189.4
Connecticut					12.6		20.3		1.5	34.4
Delaware							5.7			5.7
Florida	28.1		15.8	10.0	12.9	11.8	19.8		1.3	99.7
Georgia	51.1	24.1	6.3	21.6	23.0	16.3	25.3		.5	168.2
Idaho			92.1		15.5	5.1	3.4		.4	116.5
Illinois	76.5						535.2	6.2	2.2	620.1
Indiana	23.6						290.0		.6	314.2
Iowa	5.7		34.4				104.9		.2	145.2
Kansas	116.3	48.9	10.0		11.5		53.4	1.0	1.7	242.8
Kentucky	151.5		3.7		45.6		21.7		4.9	227.4
Louisiana	44.5		126.8				16.8		4.9	193.0
Maine			23.2		9.5		5.9		1.1	39.7
Maryland					14.8		15.2			30.0
Massachusetts				.4	42.4	19.0	9.5		.1	71.4
Michigan	25.9		23.4				277.5		1.7	328.5
Minnesota	270.4						35.1		.4	305.9
Mississippi	105.7		89.9			1.4	28.4		2.9	228.3
Missouri	97.0						35.1		.7	132.8
Montana	30.2		241.0				3.8		.6	275.6
Nebraska	182.7	457.5					2.4		1.5	644.1
Nevada	8.2		129.1							137.3
New Hampshire				5.5	2.4		11.1			19.0
New Jersey	1.7		.7		.2	.4	68.3			71.3
New Mexico	12.5		91.3	41.7			9.0		.7	155.2
New York	36.6		19.5		33.0		371.1		.4	460.6
North Carolina	33.7						55.6		.4	89.7
North Dakota	541.0	3.0	64.7	16.2					1.4	626.3
Ohio	58.2		1.7	7.8	34.9	3.4	114.9	27.2	2.1	250.2
Oklahoma	129.7				10.4		30.1		.8	171.0
Oregon	15.3		24.6						.8	40.7
Pennsylvania	48.7						177.0	13.3	1.7	240.7
Rhode Island					19.0		7.8			26.8
South Carolina	29.0	71.7	10.9			17.4	72.7		3.8	205.5
South Dakota	356.8		226.6						.6	584.0
Tennessee	100.7					7.0	29.2		2.0	138.9
Texas	131.1		14.6	3.9			73.5		1.7	224.8
Utah	29.5		73.9		4.5		4.1		.2	112.2
Vermont			6.8		5.9		38.3		.2	51.2
Virginia				8.4	63.7		26.5		.7	99.3
Washington	52.9		45.8				6.5		.2	105.4
West Virginia	69.1		5.4		11.1		19.8		.2	105.6
Wisconsin		8.1	135.1				132.2		1.8	277.2
Wyoming	175.1		35.8	11.4			4.1		.6	227.0
Hawaii							3.2			3.2
Total	3,401.5	648.2	1,831.6	136.0	378.9	100.5	2,890.8	47.7	58.7	9,493.9

TABLE 14.—*Mileage of Federal-aid roads approved for initial construction on June 30, 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Port-land cement concrete	Brick	Bridges	Total
Alabama	27.3		21.3						0.1	48.7
Arkansas	9.9									9.9
California			20.0	20.2		1.7	1.5		.3	43.7
Colorado			7.4	5.3						12.7
Connecticut							3.6			3.6
Delaware				8.0			4.9			12.9
Florida	12.6				18.0				.1	30.7
Georgia				15.4	82.8		4.1			102.3
Idaho	22.0		72.7				6.9			101.6
Illinois	36.8						111.2			148.0
Indiana	8.4						52.9			61.3
Iowa	1.4		1.7				7.1			10.2
Kansas	80.1						25.9		.3	106.3
Kentucky	62.3						.4			62.7
Louisiana	5.3								3.5	8.8
Maine			6.6		1.0		6.4		.2	14.2
Maryland					16.6	12.1	9.9			38.6
Massachusetts					5.6					5.6
Michigan							29.0		.4	29.4
Minnesota	44.0						5.6		.2	49.8
Mississippi			11.5							11.5
Missouri	20.6		5.5				19.9		.3	46.3
Montana	32.1		182.0	20.3					.7	235.1
New Hampshire							9.1		.1	9.2
New Mexico	15.3		40.5				.3			56.1
New York					27.4		89.5			116.9
North Carolina							5.0			5.0
North Dakota	191.4						.8		.2	192.4
Ohio	14.1						71.0	3.4	.1	88.6
Oklahoma	86.2				10.1		13.1		.3	109.7
Oregon	6.6								.1	6.7
Pennsylvania	2.6						79.7		.1	82.4
Rhode Island						2.5	1.5			4.0
South Carolina							10.4			10.4
South Dakota	84.8	9.2	12.9						.1	107.0
Tennessee	21.1						4.5			25.6
Texas	128.9				.9		30.4		1.7	161.9
Utah			15.0				4.4			19.4
Vermont							11.9			11.9
Virginia	6.6		.2		24.8					31.6
Washington	17.4						3.6		.2	21.2
West Virginia	19.4				5.9					25.3
Wisconsin			16.9				19.6			36.5
Wyoming	41.8									41.8
Hawaii	1.7								.1	1.8
Total	1,000.7	9.2	414.2	69.2	193.1	16.3	644.1	3.4	9.1	2,359.3

TABLE 15.—*Mileage of Federal-aid stage construction completed during the fiscal year 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama							1.9			1.9
Arizona	−4.3		4.3							
Colorado			2.9				.3			3.2
Florida			11.8	−11.8						
Georgia	.9		.2		12.0		77.8			90.9
Idaho			−1.8	18.2		15.5	.4			32.2
Iowa			−19.5				104.2			84.7
Kansas	.4	3.5					8.7	5.4		18.0
Kentucky			26.6		4.1					30.7
Louisiana						7.5				7.5
Minnesota							110.3			110.3
Mississippi			14.1				21.9			36.0
Missouri	5.7		.1				16.3			22.1
Montana			9.2							9.2
Nebraska		386.3					1.2		0.2	387.8
Nevada			13.4	13.9						27.4
North Carolina							34.4			34.4
North Dakota			394.4	4.3						398.7
Ohio							3.5	.7		4.2
Oklahoma					12.5		19.8			32.3
Oregon			38.6							38.6
Pennsylvania							3.0			3.0
South Carolina						6.2	47.4			53.6
South Dakota		7.6	185.6							193.2
Tennessee							27.4			27.4
Texas	11.5		17.2	−13.7	140.5	7.4	83.7		.1	246.6
Utah				7.5						7.5
Virginia							3.9			3.9
West Virginia					12.0	−8.0				4.0
Wisconsin			4.5				31.6			36.1
Wyoming			53.2	15.5						68.7
Total	14.2	397.4	754.8	33.9	181.1	28.6	597.7	6.1	.3	2,014.1

TABLE 16.—*Mileage of Federal-aid roads under stage construction on June 30, 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Total
Alabama		1.3					54.6	55.9
Arizona		.6						.6
California	2.0			0.6			5.6	8.2
Colorado						9.2		9.2
Delaware							3.9	3.9
Florida						5.4		5.4
Georgia				20.2			10.5	30.7
Idaho			43.5	10.3	3.0			56.8
Indiana							3.5	3.5
Iowa			37.0				100.3	137.3
Minnesota	10.3						44.4	54.7
Mississippi			6.6				24.3	30.9
Missouri	7.5						31.5	39.0
Montana				4.1				4.1
Nebraska		197.4						197.4
Nevada				28.4				28.4
North Carolina	4.2						8.8	13.0
North Dakota	20.1		145.3					165.4
Ohio							6.0	6.0
Oklahoma							6.4	6.4
South Carolina						58.7	62.0	120.7
South Dakota			67.3				6.0	73.3
Texas			3.4		46.7		75.0	125.1
Utah				12.3				12.3
Virginia	7.8				7.4		6.4	21.6
Washington	18.1							18.1
Wisconsin							25.2	25.2
Wyoming			26.2	5.9				32.1
Total	70.0	199.3	329.3	81.8	62.5	67.9	474.4	1,285.2

TABLE 17.—*Mileage of Federal-aid roads approved for stage construction on June 30, 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macad-am	Bitu-minous macad-am	Bitu-minous concrete	Portland cement concrete	Bridges	Total
Alabama							12.4		12.4
Arizona						4.2			4.2
Arkansas							6.2		6.2
Colorado				14.5					14.5
Georgia			7.7		31.6		10.8		50.1
Idaho					1.8				1.8
Iowa			22.5				48.9		71.4
Maryland					7.2				7.2
Michigan							6.5		6.5
Minnesota	20.6								20.6
Mississippi								0.6	.6
Missouri							13.7		13.7
Montana			7.8			2.9			10.7
Nebraska		23.2							23.2
Nevada				23.7					23.7
New Mexico								.5	.5
New York							8.6		8.6
North Carolina			4.0				15.5		19.5
North Dakota	1.0		120.7						121.7
Ohio							6.7		6.7
Oklahoma						7.9	7.6		15.5
South Carolina						8.1			8.1
South Dakota			39.2						39.2
Tennessee							94.3		94.3
Texas					54.3		101.7		156.0
Utah			.5	1.0					1.5
Washington							5.0		5.0
Wisconsin							15.7		15.7
Total	21.6	23.2	202.4	39.2	94.9	23.1	353.6	1.1	759.1

TABLE 18.—*Net changes in the types of Federal-aid improvements on the Federal highway system during the fiscal year 1928*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Port-land cement concrete	Brick	Bridges	Total
Alabama	−6.6	111.5	107.8		20.9		19.9		2.6	256.1
Arizona	.3	−.6	15.0	0.1			.4		.4	15.6
Arkansas	11.3		62.9		13.3		2.7		.6	90.8
California	1.7		8.5	−.1	.6	55.7	23.0		.9	90.3
Colorado	−5.4	−9.5	26.7				12.0		1.0	24.8
Connecticut				8.7	−.1	.6	44.0		2.1	55.3
Delaware					7.0	13.7	14.1	−2.1	.2	32.9
Florida	−.8	−5.5	35.0	11.3	6.3	.2	19.5		4.1	70.1
Georgia	34.7	−48.7	6.6	11.7	11.2	.9	109.3		1.9	127.6
Idaho	−43.2	−8.9	16.3	18.2		18.2	.5		1.0	2.1
Illinois					.1		142.2			142.3
Indiana	−3.5		8.7	−15.1	6.3		214.9	6.6	.6	218.5
Iowa	153.3		−19.8				272.0		.5	406.0
Kansas	329.7	74.4	31.7		16.2		110.8	19.5	3.2	585.5
Kentucky	114.9		85.6	−.1	28.8		24.3		1.5	255.0
Louisiana	.5		21.2			23.1	12.1		4.6	61.5
Maine			36.0		1.9		27.6		.2	65.7
Maryland	.1			.1	47.5		28.0			75.7
Massachusetts			.4		33.7	13.7	12.6		.1	60.5
Michigan	9.9		34.6	.1		−.1	130.4		.9	175.8
Minnesota	193.4		−8.8			.1	121.6		.1	306.4
Mississippi	13.3	−4.9	104.8				53.0	.5	5.1	171.8
Missouri	55.1		−18.5	−1.0	−.1	−.1	126.4		.1	161.9
Montana	8.0		131.9	1.9			.6		1.3	143.7
Nebraska	−168.6	912.3	−42.4			2.9	19.6	1.0	.7	725.5
Nevada	−1.7		61.4	18.6	.1	.1			−.7	77.8
New Hampshire				12.4	16.1	.3	5.9		2.4	37.1
New Jersey	2.7		.1				70.4			73.2
New Mexico	−2.2		180.4				.7		1.3	180.2
New York	10.5	4.6	23.8		13.2		332.7		.2	385.0
North Carolina		−48.6					144.7		.7	96.8
North Dakota	−97.4	−4.0	517.5	4.3					1.0	421.4
Ohio	28.1			33.6	47.8	.1	127.9	20.7	1.4	259.6
Oklahoma	95.4				22.4	−2.8	102.6			217.6
Oregon	26.0		56.1		−.1				.2	82.2
Pennsylvania	14.4				10.6	.1	172.0		.6	197.7
Rhode Island					7.7	−.1	10.3		.1	18.0

TABLE 18.—*Net changes in the types of Federal-aid improvements, etc.*—Contd.

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Port-land cement concrete	Brick	Bridges	Total
South Carolina	−18.1	−63.4	−0.2			13.6	70.9		3.0	5.8
South Dakota	−235.8	7.6	480.5				1.5		.6	254.4
Tennessee	35.4		6.8	−0.1	12.5	5.8	66.4		1.0	127.8
Texas	43.4		39.4	−13.7	247.9	14.1	120.9	−0.1	2.7	454.6
Utah	.5		76.8	7.5					.5	85.3
Vermont			−3.5	4.7	15.5		23.5		.6	40.8
Virginia	−3.9	−21.6		3.7	2.9		101.5		1.4	84.0
Washington	18.5		22.9				12.2		1.9	55.5
West Virginia	66.7			.1	43.3	−1.1	27.1		.8	136.9
Wisconsin	−1.1	−6.3	155.8	4.1	−.1		181.0			333.4
Wyoming	5.2	3.6	98.6	15.5			1.1		.6	124.6
Hawaii					13.8		15.8		.1	29.7
Total	684.7	892.0	2,360.6	126.5	647.2	159.0	3,130.6	46.1	54.1	8,100.8

TABLE 19.—*Federal-aid apportionment, and amounts paid to the States for the fiscal year 1928, and the unobligated balance of the total apportionment on June 30, 1928*

State	Apportionment fiscal year 1928	Paid to States during the fiscal year 1928	Unobligated balances of total apportionment on June 30, 1928
Alabama	$1,547,220.00	$2,759,986.85	$1,645,844.81
Arizona	1,056,994.00	422,436.01	2,896,024.65
Arkansas	1,277,896.00	796,612.86	1,766,771.75
California	2,483,437.00	2,444,944.39	3,363,012.39
Colorado	1,376,520.00	1,371,058.74	2,573,202.04
Connecticut	472,685.00	415,289.33	566,752.61
Delaware	365,625.00	396,176.60	190,680.44
Florida	899,451.00	1,261,265.91	1,210,489.75
Georgia	1,979,209.00	2,260,205.94	17,567.82
Idaho	935,193.00	936,021.88	138,890.41
Illinois	3,154,429.00	3,021,486.88	114,597.22
Indiana	1,926,772.00	2,767,823.43	267,083.14
Iowa	2,044,999.00	3,507,729.88	171,307.77
Kansas	2,068,532.00	3,071,637.66	1,284,552.84
Kentucky	1,417,947.00	2,214,946.66	529,296.09
Louisiana	1,013,308.00	959,664.41	317,573.20
Maine	680,794.00	469,884.26	1,380,996.50
Maryland	635,119.00	555,946.88	143,816.23
Massachusetts	1,089,100.00	676,811.29	2,151,418.10
Michigan	2,214,691.00	2,326,490.95	627,344.95
Minnesota	2,120,741.00	1,986,635.11	398,471.43
Mississippi	1,307,879.00	1,839,908.75	892,222.08
Missouri	2,405,175.00	2,658,532.48	1,550,939.55
Montana	1,551,499.00	1,778,896.60	4,353,988.31
Nebraska	1,585,138.00	2,653,649.87	1,999,143.13
Nevada	948,510.00	937,054.96	595,556.89
New Hampshire	365,625.00	371,194.25	65,727.25
New Jersey	934,611.00	1,319,535.00	253,177.00
New Mexico	1,186,763.00	1,417,762.65	894,813.28
New York	3,635,217.00	5,061,107.41	3,910,462.81
North Carolina	1,713,356.00	1,589,297.53	1,141,531.23
North Dakota	1,194,951.00	1,409,404.82	637,992.37
Ohio	2,762,209.00	2,183,363.28	2,591,001.85
Oklahoma	1,751,891.00	1,618,293.19	387,602.49
Oregon	1,182,202.00	658,467.98	1,267,098.47
Pennsylvania	3,335,735.00	3,031,621.22	1,850,129.27
Rhode Island	365,625.00	318,506.03	576,046.16
South Carolina	1,054,988.00	1,259,902.48	64,396.43
South Dakota	1,220,064.00	1,167,023.73	514,514.16
Tennessee	1,614,766.00	1,157,624.72	254,777.15
Texas	4,497,272.00	4,367,659.10	3,975,468.70
Utah	846,906.00	1,290,052.52	220,749.79
Vermont	365,625.00	694,117.53	25,473.81
Virginia	1,442,714.00	1,439,060.08	237,853.61
Washington	1,131,532.00	521,599.31	481,843.46
West Virginia	793,636.00	1,043,717.00	478,768.16
Wisconsin	1,870,455.00	2,959,014.72	1,435,440.82
Wyoming	934,369.00	1,106,907.83	167,116.50
Hawaii	365,625.00	325,901.59	1,064,241.58
Total	73,125,000.00	80,802,232.55	53,643,770.45

NATIONAL-FOREST ROAD CONSTRUCTION

The systems of forest roads in the several States now include a total of 13,911 miles, of which 11,767 miles are in the 12 States of the mountain and Pacific groups and the Territory of Alaska. All appropriations for forest-road construction are being expended upon these systems.

As shown by Table 20, the mileage of class 1 highways, upon which it is planned to expend, until they are completed, approximately 70 per cent of each annual appropriation, is now 1,089 miles, of which 822 miles are in the Western States. These are the more important highways which are necessary sections or extensions of the Federal-aid system wholly within the forest areas. The class 2 highways, which also extend the Federal-aid system, are increased by recent additions to a total of 7,131 miles, of which 6,887 miles are in the West. The class 3 highways, those that serve principally the communities within the forests, now aggregate 5,690 miles, of which 4,057 miles are in the Western States and Alaska.

TABLE 20.—*Classified mileage of forest highway system in several States*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Western:				
Alaska			373.8	373.8
Arizona	174.0	491.0	243.0	908.0
California	321.5	995.6	761.8	2,078.9
Colorado		1,228.0	495.0	1,723.0
Idaho		738.1	351.1	1,089.2
Montana	147.4	657.2	381.0	1,185.6
Nevada		376.4	97.0	473.4
New Mexico	115.0	211.0	199.0	525.0
Oregon	58.0	872.4	409.0	1,339.4
South Dakota	2.0	169.0	63.0	234.0
Utah		458.0	299.0	757.0
Washington	4.7	328.9	239.9	573.5
Wyoming		362.0	145.0	507.0
Total	822.6	6,887.6	4,057.6	11,767.8
Eastern:				
Alabama			45.0	45.0
Arkansas	131.0	51.0	20.0	202.0
Florida	3.0	13.0	106.0	122.0
Georgia			99.0	99.0
Kentucky		6.0	6.0	12.0
Maine			11.0	11.0
Michigan		13.4	55.0	68.4
Minnesota	41.0	38.5	142.0	221.5
Nebraska			28.8	28.8
New Hampshire	18.3	15.5	62.5	96.3
New Jersey		3.0	5.5	8.5
North Carolina	49.0		199.0	248.0
Oklahoma			33.0	33.0
Pennsylvania	24.5		173.0	197.5
Porto Rico				
South Carolina		6.0	40.0	46.0
Tennessee		55.0	189.0	244.0
Virginia		38.0	269.0	307.0
West Virginia		4.0	149.0	153.0
Total	266.8	243.4	1,632.8	2,143.0
Grand total	1,089.4	7,131.0	5,690.4	13,910.8

As shown by Table 21, 281 miles of forest highways of all classes were completed during the year. Of this total, 259 miles were in the 12 Western States and Alaska, and the remaining 22 miles were in the forests of 3 Eastern States.

The total mileage completed to date, including the results of the last year's work, is 3,775 miles, of which 3,484 miles are in the West and 291 miles in the East.

TABLE 21.—*Mileage of completed forest highway projects by States*

State	Mileage of forest highway projects completed	
	During 1928	Total to June 30, 1928
Western:		
Alaska	33.3	184.9
Arizona	24.1	261.2
California	32.0	284.1
Colorado	42.4	308.4
Idaho	22.8	462.4
Montana	21.0	364.6
Nevada	4.1	108.0
New Mexico	6.5	170.7
Oregon	57.3	573.9
South Dakota	3.1	44.6
Utah		285.0
Washington	7.6	195.9
Wyoming	5.3	240.2
Total	259.5	3,483.9
Eastern:		
Alabama		5.1
Arkansas		56.8
Florida		64.2
Georgia	2.8	21.4
Kentucky		
Maine		
Michigan	8.1	8.1
Minnesota		34.6
Nebraska		
New Hampshire		3.6
New Jersey		
North Carolina		36.3
Oklahoma		
Pennsylvania		
Porto Rico		
South Carolina	10.7	16.0
Tennessee		33.5
Virginia		11.9
West Virginia		
Total	21.6	291.5
Grand total	281.1	3,775.4

Among the more important roads completed during the year are sections of the Moose Pass, Mill Creek, Tongass, and Glacier highways in Alaska; the Salt River-Pleasant Valley highway and Swift Trail in Arizona; the Emigrant Gap, Truckee-Meyers, and Mendocino Pass highways in California; the mountain crossings through Cumbres, Fremont, Tennessee, and Independence Passes, and a section of the Mount Evans highway in Colorado; the Clark Fork, Ketchum-Clayton, and Salmon-Montana line highways in Idaho; the Columbia Falls-Glacier Park and Roosevelt highways and the Yellowstone Trail in Montana; the Conner's Pass highway in Nevada; the Pleasanton-Box Canyon highway in New Mexico; the Canyon City-Burns, Flora-Enterprise, Klamath Falls-Lakeview, Heppner-Spray, Santiam, and Roosevelt coast highways in Oregon; the Republic-South and Olympic highways in Washington; and the Dayton-Steamboat Rock, and Hoback Canyon highways in Wyoming.

Construction of a number of important bridges was also completed during the year. Among these may be mentioned the Crooked Fork bridge on the Lewis and Clark highway in Idaho; the Coram-Spotted Bear, Hannan Point, and Ear Mountain bridges in Montana; and the Jackson Park bridge in Wyoming.

Additional work, involving surfacing and in some cases reconstruction, was completed on the following projects: The Saxman-Mountain Point section of the Tongass highway, and two sections of the Salmon River project in Alaska; the Flagstaff-Angell project in Arizona; the Yuba Pass project in California; the Tennessee Pass project in Colorado; the McCall-New Meadows, Salmon-Montana line projects, and the Kooskia-Lowell, middle section of the Lewis and Clark highway in Idaho, the latter involving reconstruction; reconstruction and surfacing on the Belt Creek and Sheep Creek sections of the Y. G. B. line in Montana; surfacing of the Scott Creek section of the Alsea River project, the Wapinitia section of the Mount Hood-Wapinitia project, and the Trail-Park Boundary and Flora-Enterprise projects, all in Oregon, and reconstruction and surfacing of the Mount Hood Loop and Oregon Caves projects in the same State; and reconstruction and surfacing of the Junction-Escalante project in Utah, the Excelsior-Shuksan section of the Mount Baker project in Washington, and the Buffalo-Ten Sleep project in Wyoming.

Extensive use has been made during the year of asphaltic fuel-oil treatments of fine crushed gravel and rock roads. This treatment has been used both as a maintenance and a construction measure. It greatly improves the fine crushed rock surfaces, of which so many miles have been built, by eliminating dust and reducing surface wear.

Two general methods are in use, known, respectively, as the surface treatment and mixing methods. The latter gives promise of wider adaptability and more durable results. It consists essentially of the incorporation of a suitable quantity of asphaltic fuel oil, generally 1.5 gallons per square yard, into the upper 3 inches of the crushed-rock surfacing. The cost of a treatment of this kind ranges from $1,200 to $1,700 per mile, under efficient management. Surface treatment has also given excellent results where sufficient attention has been given to prior smoothing and compacting of the crushed-stone layer. The quantity of oil required for the surface treatment is only about a half gallon per square yard, but the stone chips that must be applied for the protection of traffic bring the construction cost nearly to that of the mixing treatment, and the maintenance cost is generally higher. Both methods are more than saving their cost by conserving material, and in addition they contribute materially to the comfort and safety of travel and considerably reduce the tractive resistance of the road surface and consequently the expense of operating vehicles.

The survey of the highway needs of sections of Alaska, mentioned in the last annual report, is being continued. As previously stated, one of the principal purposes of the survey is to ascertain what may and should be done by highway construction to develop the mineral deposits, forest resources, water power, and other natural possibilities of southeastern Alaska.

SURVEYS AND CONSTRUCTION IN THE NATIONAL PARKS

In furtherance of the national-park program there was brought to completion during the year, under the bureau's supervision, the improvement of nearly 42 miles of road in five national parks. This work was done under the agreement with the National Park Service by which the bureau has undertaken to survey and supervise the construction of roads in the 1,500-mile, 5-year program of national-park road improvement which has been mapped out. The

roads completed this year bring the total completed under the bureau's supervision to nearly 120 miles; and at the close of the year there were 164 miles additional which were under construction and 322 miles on which surveys were in progress.

The mileage included in the 5-year program in each of the parks, and the mileage completed under the bureau's supervision during the last year and to date, are shown in Table 22.

TABLE 22.—*The 5-year program of national-park road improvement, and the mileage of roads improved under the supervision of the Bureau of Public Roads*

National park	Mileage of the 5-year program	Mileage completed under the supervision of the bureau	
		During the fiscal year 1928	Total to June 30, 1928
Western:			
Crater Lake	80.2	1.3	17.5
Glacier	141.5	-------	5.5
Mount Rainier	112.7	11.8	11.8
Grand Canyon	149.4	-------	12.3
Yosemite	217.8	13.8	27.4
Sequoia and General Grant	115.0	3.8	26.4
Lassen Volcanic	45.6	-------	5.8
Yellowstone	358.4	-------	-------
Rocky Mountain	63.7	-------	1.8
Mesa Verde	47.3	-------	-------
Zion	23.2	-------	-------
Hawaii	81.0	11.2	11.2
Mount McKinley	73.5	-------	-------
Total	1,509.3	41.9	119.7
Eastern: Lafayette	4.5	-------	-------
Grand total	1,513.8	41.9	119.7

Of outstanding interest among the projects at present under construction are the Transmountain Highway in Glacier National Park, which is rapidly nearing completion; the Zion-Mount Carmel project in Zion Park, on which the tunneling is an especially interesting feature; the road surfacing projects in Yosemite; the work on the north and south rim roads at the Grand Canyon; and the stage construction betterments of the West Side Highway in Mount Rainier National Park.

In all this work in the national parks special attention is given to the development of aesthetic features of the roads and bridges, and every possible effort is made to avoid scarring the landscape and to preserve the scenic beauties for which the parks are famous.

The fact that the bureau has engineering direction of the work in both the national forests and the national parks has facilitated the solution of problems of correlation between the park roads and those of the surrounding and intervening forests. Several major problems have developed. The two isolated areas of the Grand Canyon Park will have to be connected by a road which must extend through the Kaibab Forest and the House Rock Valley to a crossing of the Colorado at Lees Ferry and thence through the Navajo Indian Reservation on the south side. Some progress has been made in the construction of the Lees Ferry Bridge, but before the route can be developed to full use many miles of road must be built.

Sequoia and General Grant Parks are separated by forest area, through which a road must be constructed as a link in the General's Highway. On the Belton-Glacier forest project there still remains a section of 25 miles to link the two sides of Glacier Park. Much further work is needed, also, on the east and south entrance roads to Yellowstone Park, both within national forests; and provision must be made for the Big Oak Flat and Wawona entrances to Yosemite, both largely within the forest. For Mount Ranier Park a much needed entrance from White River is now under construction as a forest project and an approach to the northwest corner of the park from Fairfax is planned.

The forest and park roads are developing such importance that the question of snow removal must be given careful consideration. During the past winter snow was removed by the State of Colorado on the Tennessee Pass forest project over the Continental Divide. (Elevation 10,400 feet.) The previous winter Berthoud Pass was kept open into February, when the national funds available became exhausted. Other important forest projects which were open during the winter are the Flagstaff-Angel and Prescott-White Spar project in Arizona; the Canoncito-Pecos project in New Mexico; and the Bear Valley and Swartout projects in California. Snow removal on these projects was made possible by the study given this problem when the locations were made.

SPECIAL ROAD PROJECTS

SURVEY OF FLOOD DAMAGE IN VERMONT AND NEW HAMPSHIRE

Following the unprecedented flood which occurred in Vermont and New

Hampshire in November, 1927, the bureau was requested by the governors of the two States to make a survey of the resulting damage to roads and bridges and estimate the cost, as the basis for a determination of the funds required to replace or repair the damaged highways and bridges.

In compliance with these requests a special force of engineers was organized from the personnel of the bureau, the survey was made, and a report was rendered, in a little more than a month's time, which placed the cost of the damage in Vermont at approximately $7,400,000, and that in New Hampshire at $2,700,000.

As a measure of immediate relief in Vermont it was necessary to replace two important bridges over the Winooski River, both of which had been washed away. As the railroad through this river valley was damaged beyond hope of immediate repair it was necessary that both of these bridges be replaced as rapidly as possible in order that the work of rehabilitating the devastated area might be expedited in anticipation of the coming winter.

The responsibility for the construction of one of the two bridges, that at Middlesex, Vt., was accepted by the bureau. A temporary bridge was designed which could be built of materials available in the vicinity; and in 12 days from the arrival of the materials at the site, the bridge was completed at a cost of approximately $9,000, much of which is salvable.

In connection with the survey of damage, the bureau also made special hydrographic and rainfall studies, assembled eye-witness reports of high-water stages at various points, and accumulated a mass of data and evidence which will be of great value in the future design of bridges and road grades in the area affected.

MOUNT VERNON MEMORIAL HIGHWAY

On May 24. 1928, the President signed the act authorizing and directing the survey, construction, and maintenance, under the supervision of the Secretary of Agriculture, of a memorial highway to connect Mount Vernon, the home of George Washington, with the Arlington Memorial bridge over the Potomac River at Washington. The act authorizes the appropriation of the following sums, to be available until expended: $500,000 for the fiscal year 1928, $2,000.000 for the fiscal year 1929, and $1,000,000 for each of the fiscal years 1930 and 1931. It is the purpose to complete the highway by 1932 in order that it may be officially opened and dedicated as an incident of the celebration of the bicentennial of the birth of Washington in that year.

Prior to the passage of the act the bureau had made reconnoissance surveys of two possible locations at the request of the Committee on Roads of the House of Representatives and had furnished the committee with an estimate of the cost of constructing the road on a suitable location.

Since the passage of the act the Secretary of Agriculture has delegated the duty of surveying and supervising the construction of the highway to this bureau; and detailed surveys with the object to fixing the final location were begun on June 15, 1928. Work on these surveys will be prosecuted with all possible vigor, and it is hoped that a final decision on the location may be possible in time to let contracts and start the grading during the fall of 1928 in order to allow as much time as possible for the consolidation of the fills before surfacing is applied.

HIGHWAY RESEARCH

THE CLEVELAND HIGHWAY PLANNING SURVEY

The outstanding economic research project of the year was the survey of traffic and study of the causes of traffic congestion in the metropolitan region surrounding the city of Cleveland, Ohio. This project, initiated at the request of the board of county commissioners of Cuyahoga County, Ohio, in September, 1927, and conducted in cooperation with that body and with the assistance of officials of other counties and numerous cities, villages, and townships in the metropolitan region, was completed during the fiscal year.

As a result of the survey a plan for the future development of the existing roads of the area and the construction of new arterial, by-pass, and relief highways has been prepared by the bureau and enthusiastically adopted by the authorities of all jurisdictions concerned, and active preparations are now being made to construct the planned improvements.

As a basis for the plan, a great mass of data was obtained concerning the average and maximum density of traffic on all important highways in the area; the origin and destination of the traffic; the most direct routes from origin to destination of the large movements, and the causes of habitual departure from such routes where it was

found that traffic was not following the direct route; the habitual speed of traffic and conditions influencing speed and causing congestion, such as grade crossings, street-car tracks and loading platforms, traffic lights, the convergence of heavily traveled highways, etc.; the width of pavement required to accommodate various densities of traffic; the possibility of establishing new routes which will relieve congestion on present routes and provide more direct communication between various areas; and other facts of similar fundamental importance.

This mass of data was carefully analyzed, and, after a detailed study and appraisal of the condition and availability of existing pavements, a plan of new construction, resurfacing, and surface widening was drawn up which utilizes to the greatest possible degree the improvements previously made in the area. Because of the thoroughness of the study there is high confidence that the plan developed will provide a satisfactory solution of the intricate traffic problems of this important area and will do so with economy.

Not the least of the accomplishments in connection with this survey and plan, of which the bureau is especially proud, is the success which attended its efforts to bring together and harmonize the interests of the many more or less independent jurisdictions involved, without which no consistent highway development in the area would be possible. The beneficial results of this cooperation which will shortly be manifested in concrete form may well serve as an object lesson to other communities similarly constituted and beset by similar problems.

PHYSICAL RESEARCHES

The physical researches of the bureau relate to the character and use of highway materials and to the behavior of highway structures. The purpose of this work is to develop scientific facts which may serve as a basis for the establishment of sound engineering practices and which will result in effective and economical highway construction. The investigations include detailed studies to determine the characteristics of the various materials, the comparative values of different materials which may be used for the same purpose and the best methods of using them in construction, the forces which tend to destroy highways and the most effective means of resisting these destructive forces, and the manner in which the various materials and combinations of materials fulfill their purpose.

The value of this work can scarcely be overestimated. This is due to the fact that the results are multiplied in their application year after year to a vast mileage of roads still to be built or rebuilt. The comparatively small saving made possible by the improvement of just one material or item of construction is multiplied time after time by repeated use of the improvement on each mile of road in which the particular material or item is involved. In time there is returned to the public a saving out of all proportion to the comparatively small expense of the research which made it possible.

The following description summarizes briefly the more important of the physical researches which have been current during the past year.

SUBGRADE INVESTIGATIONS

It is the present practice in road construction to build pavements without regard to variable subgrade conditions. A pavement which is heavy enough for the good subgrades may fail in those portions where the subgrade is bad. If it is heavy enough for the bad subgrades it is unnecessarily heavy, and therefore unduly expensive, for the portions of the road where the subgrade is good. It has been estimated that in certain localities the difference in cost between a concrete pavement suitable for a good subgrade and one suitable for a poor subgrade may amount to as much as $3,000 per mile, or from 10 to 15 per cent of the total cost. Considering the great mileage of highways which must be paved, it can be appreciated that the savings which will result from an accurate knowledge of subgrades may be enormous.

For these reasons the subgrade investigations which are now under way are considered as among the most important of the bureau's physical researches. They are perhaps also the most difficult of the investigations with which the bureau is at present concerned, for they constitute a fundamental research in a problem of extreme complexity.

Laboratory and field investigations are being carried on simultaneously to develop the required information. In the laboratory a study is being made of various tests which will serve to identify and classify soils for the purposes of the highway engineer. In this work advantage is being taken

of the extensive work of the United States Bureau of Chemistry and Soils in the classification of soils for agricultural purposes. In the field, surveys of roads and pavements are being made in different parts of the country, where the conditions are most favorable for such work, to determine the influence of soil characteristics on pavement behavior and to observe the efficiency of the various corrective measures which are being used to improve poor subgrades. A laboratory and field investigation of the failure of roads due to frost action is also in progress.

The subgrade investigation requires the concerted efforts of the physicist, the soil scientist, and the highway engineer. Certain portions of the work are conducted independently by the Bureau of Public Roads, while others are conducted with the cooperation of the Bureau of Chemistry and Soils, the Massachusetts Institute of Technology, the Ohio State University, and the University of South Carolina.

In research of this character rapid progress is not to be expected since the procedure can not be outlined in advance but must be developed step by step and with extreme care, using as a basis the information made available by the preceding phases of the work. However, definite progress is being made. Already it has been possible to develop a soil classification, useful for highway purposes, and to establish, within broad limits, practices in design and construction which promise success when applied to the building of roads involving possible combinations of the various types of road surface with the various classes of soils.

Somewhat related to the problems connected with subgrades is the problem of landslides. Landslides are responsible not only for the expenditure of enormous sums annually for extra highway maintenance, but they are a menace to the safety of the traveler and seriously interfere with the flow of highway traffic. In general, it may be said that the present methods of road construction and maintenance aim only at the correction of the damage due to slides after they have occurred and make little attempt to control the causes which produce them. In many instances such methods promise nothing more than an almost indefinite continuation of the existing trouble.

The bureau has made a survey of slide conditions in Ohio, West Virginia, and Pennsylvania, as a result of which it is believed that the cooperation of geologist and engineer can do much to improve conditions. Even a partial alleviation of present troubles is of sufficient importance to justify a comprehensive study of the situation. Suitable drainage is indicated as the necessary corrective measure which will be effective in a large majority of cases.

LOW-COST ROAD INVESTIGATIONS

Outstanding in the research developments of the past year have been the results of the study of light oil treatments of crushed rock and gravel roads in the Western States. Thousands of miles of such roads have been constructed and have proved adequate for the traffic. However, they have been found to have two serious defects. They are extremely dusty in dry weather, in some cases to such an extent as to seriously menace the safety of traffic, and they are worn down rapidly by the wheels of vehicles. In some cases from 1 to 1½ inches of surfacing material may be lost in a year. The yearly cost of replacing this lost material may easily amount to as much as $1,000 per mile. To eliminate these objectionable features, methods of treatment with light asphaltic oils have been developed and used in Oregon and California.

With the cooperation of the California Highway Commission, the bureau has made an extensive study of this type of improvement. A report describing the methods of treatment and the essential principles necessary for successful construction has been published during the year and distributed to highway officials throughout the country. This report has proved to be of immediate value, for already a number of the States are using the new methods in construction and maintenance work.

In South Carolina the cooperation with the State highway department, in the treatment of sand-clay and topsoil roads with tars and asphalts, has been continued, and a valuable report describing the earlier experiments has been issued. The objectionable features of untreated sand-clay and topsoil roads are similar, in some respects, to those of the crushed-rock and gravel roads of the West, in that they wear rapidly and are extremely dusty in dry weather. In addition to these defects, many of them become muddy during periods of wet weather. The experiments have been so successful in developing satisfactory low-cost surface

treatments for roads of this type, resulting in greatly improved all-weather service, that considerable mileages of highways have already been improved by the new methods. Sand-clay and topsoil are used extensively in the Southern States for the construction of light-traffic roads, since the materials are readily available in many sections and relatively inexpensive. This investigation has produced results of great value to that section of the country.

In the coastal plain region of the South Atlantic States there are large areas where the use of the local materials produces unstable and extremely unsatisfactory soil-type roads and where the better classes of materials are unduly expensive on account of distance from the source of supply. The cooperative experimental work in South Carolina has been extended to this area for the purpose of developing "mixed-in-place" treatments which will stabilize the soil-type roads which now exist and thus increase their service value. The experimental sections which have been constructed are not yet of sufficient age to permit of definite statements as to their value but the present indications are that the "mixed-in-place" type of construction may be used with the materials locally available to produce economical and serviceable light-traffic roads.

VIRGINIA DEMONSTRATION ROAD

What is known as the Virginia demonstration road is a research project of more than usual interest and one which it is believed will eventually rank in importance with the Bates Road (Illinois) and Pittsburg (California) tests. Unlike the previous test roads, the demonstration road was not built primarily for testing purposes and does not constitute a test of road design or of surfacing materials. It is a concrete-paved highway, built for and carrying the regular highway traffic. The investigations which are being made are studies of the effect of variable subgrade conditions and various construction practices, such as methods of placing, finishing, and curing concrete and the use of joints of different types.

The road is located in northern Virginia between Fairfax and Warrenton. It is a Federal-aid project, and the experimental features are handled cooperatively by the bureau and the Virginia Highway Commission. The test sections, which are 60 in number and have a total length of approximately 12 miles, were built during the construction seasons of 1926 and 1927. Observations covering a period of several years will be necessary to determine the influence of the variables which are included in the study. This demonstration is claiming the attention of highway officials throughout the country and the knowledge which will be gained will undoubted y exert a major influence on future highway construction. A progress report descriptive of the project has been published.

CONNECTICUT AVENUE EXPERIMENTAL ROAD

The Connecticut Avenue experimental road, extending from Chevy Chase Circle to Chevy Chase Lake in Montgomery County, Md., was constructed by the bureau during the years 1911, 1912, and 1913. The experiment involved the construction and subsequent observation of numerous types of pavement, including bituminous penetration macadams, surface-treated macadams, Portland cement concrete pavements, and asphaltic concrete and brick wearing surfaces on Portland cement concrete bases. During the ensuing 15 to 17 years the road has been subjected to a very heavy traffic. Throughout this period it has been maintained by the bureau, and the maintenance costs, together with the observed behavior of each section, have been carefully recorded.

The experiment is unique in that it has made available accurate maintenance costs, extending over a considerable period of time, for a number of the more important types of pavement construction. In addition to this it has yielded much valuable information regarding the effect of various design and construction practices on the subsequent behavior of these types of pavements. During the year there has been published an instructive report describing in detail the present condition of the experimental sections and the yearly costs of preserving their surfaces in serviceable condition.

MOTOR-TRUCK IMPACT INVESTIGATIONS

The impact forces delivered to a pavement by the hammerlike blows of the wheels of a moving truck may be enormous as compared with the weight of the same wheels at rest. It is essential to have a knowledge of these impact forces and the variables

which determine their magnitude. This is necessary for two reasons: (1) In order that pavements may be built strong enough so that they will not fail under traffic conditions, and (2) in order that reasonable regulations may be developed to govern the operation of vehicles. The interrelationship between the highway and the vehicle is such that highway design and vehicle regulation must be adjusted to each other so as to result in maximum economy. The economic development of highway transportation must be encouraged, and at the same time the enormous investment in highways must be safeguarded.

The Bureau of Public Roads has been a leader in the study of the factors in motor-vehicle operation which influence the destructive effect on the highway. Past work in this field has served to produce the complicated instruments necessary for the measurement of the instantaneous blows of truck wheels and to develop the basic data which may now be utilized in more extended studies which will yield results of the greatest practical usefulness. The work is being continued with the cooperation, as in the past, of the Society of Automotive Engineers, representing the interests of the motor-vehicle manufacturers, and the Rubber Association of America, representing the manufacturers of rubber tires.

One of the current motor-truck impact investigations is to determine if the use of special types of resilient or cushion wheels has any tendency to decrease the destructive effect of the impact forces. This study was prompted by the possibility that improvements in wheel design may be fully as important in reducing impact forces as are improvements in tire design.

Another investigation, which was made during the past year and concerning which a report has been issued, was to answer the question which has been raised repeatedly during the past as to whether or not certain types of pavements, notably asphaltic surfaces on concrete bases, possess cushioning or shock-absorbing properties, by virtue of which the pavement base is protected from the full effect of the impact forces. This information is required if competing types of pavements are to be designed on a comparable strength basis. As a result of these tests it was concluded that there is no appreciable difference in the cushioning properties of the rigid-type pavements, irrespective of the type of wearing surface which may be used.

HIGHWAY-BRIDGE INVESTIGATIONS

The rapid development of the present highway program has resulted in an immediate need for information relative to so many phases of the work that many investigations, important in themselves but less urgently needed, have of necessity been deferred. At present the fundamentals of bridge design are much more thoroughly understood than are those of many other phases of highway construction and for this reason it has been necessary, temporarily, to relegate to the background desirable researches relating to the design of drainage structures. In spite of this necessity the bureau has engaged in some rather important bridge investigations, the more notable of the recent ones being the Delaware River bridge tests and the North Carolina bridge tests.

The Delaware River bridge investigation, which was completed prior to the beginning of this fiscal year, was described in the last annual report. A report, giving the results of the investigation, has been published during the year.

In the previous report mention was made of the proposed loading tests on a large concrete arch bridge of modern construction. The bridge in question, which was built in 1922 as a Federal-aid project, was located on the Pee Dee River near Albemarle, N. C. It consisted of three concrete, open-spandrel, arch spans of about 150 feet each and 14 concrete, deck-girder, approach spans of about 40 feet each, the total length of the structure being approximately 1,070 feet. A dam, which was built several miles downstream for power-development purposes, made necessary the destruction of the bridge since it would have been completely submerged by the impounded water. A new bridge was constructed at a higher level to replace it and the older structure was thus made available for test in the interval prior to the completion of the dam.

Advantage was taken of this unusual opportunity and a program of loading tests has been conducted cooperatively by the Bureau of Public Roads and the North Carolina State Highway Commission with the advice and assistance of a committee of distinguished representatives of a number of the national engineering organizations.

The loading tests were made with two large timber tanks filled with water, the loaded weight of each tank being approximately 160 tons. Stress

measurements were made under various conditions of loading for comparison with the stresses computed by theoretical methods of analysis. Tests of this character could ordinarily be made only at enormous expense for the test loads were carried to a point which resulted in serious damage to the structure. Upon completion of the loading tests the bridge was destroyed, under the direction of the War Department, by demolition tests with explosives.

The accepted methods of concrete arch design are based on theory. Experience has shown that these methods result in the construction of bridges of ample strength for the loads intended but the opportunity has never before been given to test the theory by the experimental loading of a large arch bridge where damage to the structure was of no consequence. A report of this work will be published during the next year.

CONCRETE INVESTIGATIONS

The physical variations which affect the strength and integrity of concrete and the effects of certain external forces on concrete structures are, as yet, most imperfectly understood. The bureau, in common with other research agencies, is carrying on extensive investigations in many phases of this subject, which is one of considerable importance in bridge and pavement construction.

Some of the factors which affect the quality of concrete are quality of cement; type, quality and gradation of fine and coarse aggregates; proportions in which the constituent materials are combined; admixtures of other materials which may be added for any one of several purposes; and methods of curing. On the quality of the concrete is dependent its ability to resist destruction. It must withstand the stresses produced by external loads, such as the wheel loads of vehicles, and the internal forces resulting from changes in length due to variations in temperature and moisture. In pavements it must resist the abrasive action of the wheels of vehicles; when exposed to the weather it must resist frost and other weathering action; and in certain conditions of exposure it must resist the destructive effects of salt water or alkali. With all of these problems the researches of the bureau have been concerned.

Among the more important concrete researches now in progress are the studies of concrete-curing methods, tests to determine the effect of variations in type and gradation of coarse aggregates on the strength of concrete, the effect of type of aggregate on the resistance of concrete to frost action, and investigations of methods for protecting concrete from the effects of sulphate waters.

DEVELOPMENT OF SPECIAL APPARATUS

In connection with many of the investigations of the bureau there has arisen the necessity for developing and constructing scientific apparatus and equipment for special purposes. Some notable achievements have been made in this field. Among the more important of the recent inventions are the relative roughness indicator for measuring the roughness of road surfaces and the traffic flow recorder for use in connection with traffic surveys.

The knowledge that smoothness of road surface is an important consideration in pavement construction has created a demand for a simple and convenient instrument which will give a relative measure of this quality. To meet this demand the bureau developed the relative roughness indicator or "roughometer," a comparatively simple device which may be attached to any automobile. The instrument is based on the principle that the amount of spring deflection of an automobile bears a direct relation to the degree of road roughness. The record give the total amount of spring compression in inches for any given distance and a comparison of records obtained on different roads gives a relative measure of their roughness. A number of the instruments are being used by the various State highway departments and one is in use by the Swedish Institute of Roads.

The traffic-flow recorder is a device designed to measure and record the speed of a vehicle at any instant and simultaneously to record the time and distance from any fixed point at the beginning of a trip. It consists of a clock, an odometer, and a speedometer, all so mounted in a box within the field of a camera that they can be photographed simultaneously. The instrument is used to measure and record the variable speed of highway traffic and the simultaneous records of time, speed, and distance which can be made at any instant furnish the data necessary for studies of the flow of traffic as affected by obstructions, congestion, or other variables. It has been used successfully in the cooperative highway

planning survey in the Cleveland metropolitan region.

STUDIES OF HIGHWAY PRODUCTION ECONOMICS

In this field the work of the past year which is worthy of special mention has dealt with three problems, as follows: (1) The possibility of reducing the cost of pavement concrete, without detriment to its strength and uniformity, by reducing the length of the mixing period; (2) the possibility of reducing costs and improving the surface smoothness of asphaltic pavements by the use of mechanical finishing methods; and (3) the economies possible in the use of power shovels in highway grading.

CONCRETE MIXING TIME STUDIES

To reduce costs, waste must be eliminated wherever possible, and ways and means must be sought to utilize equipment to its most economic capacity to develop the rate of production to its economic optimum without imparing the quality of the finished product. Since most road-construction work involves one or more operations which are repeated over and over again many times each hour, one of the most important factors in determining the cost of performing such work is the length of time required for each of these repetitive operations. This is especially true in those lines of work in which the type of the equipment and construction methods so fix the daily cost of operation that it is very largely independent of the rate of production. Concrete road construction is a good example of this class of work. The daily cost of operation for any particular modern outfit varies but little whether the rate of production is high or low. Furthermore, the maximum possible rate of production is definitely fixed by the time required to put the batch through the mixer. Thus, if 1½ minutes are required to put a batch through the mixer, then 40 batches per hour is the maximum possible rate of production, no matter how perfectly all subsidiary operations are synchronized. But if the time required for putting a batch through the mixer can be reduced to one minute then the possible rate of production rises to 60 batches per hour, or an increase of 50 per cent.

Since the time required to put a batch through the mixer is determined so largely by the length of time the materials must be held in the drum for mixing, the question at once arises as to how long a mixing time is really necessary with our modern pavers in order to produce a satisfactory concrete. As little or no definite data were available to answer this very important economic question, the study was made sufficiently extensive to cover the normal range of actual field conditions as to equipment, materials, and any regional variations in methods or practices. These studies extended over a period of more than two years, covered 24 jobs in seven States, and involved the making and testing of more than 2,000 cylinders, as well as many beams and cores.

The result of these studies, which has just been published, shows conclusively that with our modern pavers the customary mixing time can safely be reduced to one minute without detriment to the strength of the finished roadway.

STUDIES OF MECHANICAL FINISHING METHODS FOR BITUMINOUS PAVEMENTS

In the construction of bituminous pavements one of the time and labor consuming operations is that of so spreading the hot material as to secure a smooth and uniformly compacted road surface. While the bureau's studies of mechanical methods for performing this operation are as yet far from complete, they have progressed sufficiently to show that the ordinary mechanical finishing machine so generally used in concrete road construction work can readily be equally adapted to bituminous road construction. In a number of cases so far studied, not only has the use of the mechanical finisher produced a smoother riding surface, but it has also permitted the handling of more material at a lower labor cost. Thus, on a job in Hughes County, Okla., the spreading and raking when performed by hand methods placed a definite limit to the amount of rock asphalt surfacing which could be placed per hour. After the installation of a mechanical finishing machine the average rate of surfacing placed per hour of operation was increased from 218 square yards to 334, which was the limiting output of the heating plant. Other items of interest noted on this project were that with hand raking the labor cost of the entire road crew was $12.50 per hour, but after the finisher was installed the labor cost was reduced to $8.05 per hour, al-

though more than 50 per cent more material was being placed, and that with the mechanical finisher the material was being spread as readily when it reached the road at a temperature of 300° to 325° F. as was possible by hand methods when the temperature of the material was 375°. While the above job probably presented unusually favorable conditions for the use of the mechanical finisher, all the bureau's studies to date indicate that, even under the most unfavorable conditions, a proper use of the mechanical finisher will produce a smoother and more uniform riding surface and also handle a larger yardage of material than can ordinarily be done by present methods of hand raking.

EFFICIENCY IN POWER-SHOVEL OPERATIONS

The more important factors which affect the rate of production and unit costs in highway grading work with the power shovel have been described during the past year in the bureau's magazine, Public Roads. These studies are the result of four years of extensive field work and the analysis of more than a hundred grading projects.

The cost of grading is perhaps the largest single item in the highway bill of the country and a great deal of this grading is done with the power shovel. For this reason alone the question of whether or not the efficiency with which these important tools are operated and whether or not their present rates of operating efficiency can be increased is of great economic importance.

These studies have brought out very clearly how the operation of the power shovel involves not only a large number of repetitive operations but also several independent operations, all of which must be properly synchronized. First, the dipper must be loaded, swung, and spotted over the hauling unit, the load dumped, and the dipper returned for another load. From time to time the shovel must be moved forward or maneuvered so as to keep it within digging reach of the material in which it is working. But, except when casting is possible, a shovel can dig only when and as hauling units are in place to receive the excavated material. Every interruption in the steady supply of hauling units in proper place at the shovel is therefore inevitably registered as a reduction in production. Furthermore, the hauling equipment can handle material no faster than it can be received at the dump. Consequently, all these operations must not only be performed at the proper rate of speed but must also be properly synchronized in order to attain any reasonable degree of efficiency, because as these operations are repeated over and over again throughout the day, a few seconds or even fractions of seconds regularly lost in any part of these operations inevitably results in a loss in productivity which soon amounts to large proportions.

In practically all highway grading work with the power shovel the length of haul is not constant, but fluctuates, often with great rapidity and between very wide limits. Since actual job conditions usually make it impossible for the contractor to vary the number of his hauling units in accordance with the fluctuations in the length of the haul, one of the most difficult questions facing the highway grading contractor who operates a power shovel is, "What kind and how many hauling units should be placed on a particular job in order to complete the work at the lowest possible cost?" These studies have developed a practical method, which is given in considerable detail, by means of which the number of hauling units of any given kind which should be placed on a given job can be determined with reasonable accuracy.

IRRIGATION INVESTIGATIONS

DUTY OF WATER STUDIES

During the year there has been published the second of a series of bulletins on irrigation requirements of arid and semiarid lands. It covers the Missouri and Arkansas River Basins. A manuscript for the third bulletin of the series, dealing with the Southwest, has been prepared, and data now are being compiled for the fourth of the series, on the Northwest.

Because the natural water supply of southern California is exceedingly limited and the demands for water are great and constantly increasing, the economic use of water in that locality is being studied intensively. In cooperation with the State department of public works, experiments are being carried on in different sections of that part of the State to determine the least amount of water that may be applied in irrigation for economic crop production. A report on the San Diego area is now being prepared. Similar studies are being made in Orange, Riverside, and San Bernardino Counties. A special cooperative investigation has been started to determine the penetra-

tion and storage of rain falling upon the valley floor of the Santa Ana River area in Orange, Riverside, and San Bernardino Counties. In cooperation with the city of Los Angeles, studies have been made in San Fernando Valley, where approximately 60,000 acres are irrigated from the Los Angeles aqueduct. Cloudbursts have several times disabled the main aqueduct and forced restriction of the use of irrigation water, and at such periods the problem of allotting water fairly for each kind of crop and deciding their priority is a perplexing one. The investigation is for the purpose of determining the amount of water required for profitable crop production, and a more efficient use; the field work consists of (1) general duty of water studies, based on the measured amount of water applied to each farm in the valley, and (2) consumptive-use studies, based on soil-moisture investigations.

LOSS OF WATER BY EVAPORATION

During the season of 1927–28, the study of the evaporation from tanks of different types and sizes was continued. Three standard types were used, and for comparison observations were made on a copper-lined concrete reservoir 84.8 feet in diameter All the tanks were exposed under the same meteorological conditions. The results show that the small tanks all lose water at a higher rate than the large reservoir.

Observations were made to determine the effect of altitude on evaporation from a free water surface, and some special tests were carried on to find the effect of temperature on the equipment used in the evaporation experiments under controlled conditions in the laboratory. The latter experiments show that although temperature does affect the results, the magnitude of the effect is not as great as previously thought and that the effect may be eliminated by measuring the evaporation between points of equal temperature.

Observations were also made on the evaporation from a heated water surface under outside conditions in the winter, and an attempt was made to measure the evaporation from ice. During the experiments on evaporation from a heated water surface, although the air temperature dropped below freezing on several occasions, the evaporation remained about equal to the summer rate. The experiments on the evaporation from ice were not successful because the water melting from the ice during warm periods spilled from the evaporation pan, but some tests made in the laboratory without wind show that there is an appreciable evaporation from ice.

Data have been obtained relative to evaporation from moist soils, using loam, heavy adobe, and fine river sand containing some silt. When the depths of water table were 1, 6, and 12 inches, evaporation from the sand was about equal to that from a free water surface; the loam showed a decrease at the greatest depth, and the adobe at both lower depths.

PUMPING FOR IRRIGATION

A manuscript on pumping for irrigation has been completed which discusses the methods and practices followed in certain representative districts in the western United States, the economic problems which limit the profitable utilization of the pump in irrigation practice, a procedure for determining whether a pumping venture may succeed, types of standard equipment and their uses, a study of plant efficiency, and power and power problems

IRRIGATION NEEDS AND POSSIBILITIES OF THE GREAT PLAINS

The studies of this subject lead to the belief that the most important industry of the region will always be the production of animal products, and that this industry can best be practiced by a combination of the usual types of plains farming supplemented by irrigation for growing special crops that are found peculiarly suited to certain localities, such as celery near Kearney, Nebr.; cantaloupes near Rocky Ford, Colo.; and spinach near Austin, Tex. Intensive farming results in the development of towns and communities that afford marketing centers, and educational and entertainment facilities not available in more sparsely settled areas.

DESIGN, INVENTION, AND TESTING OF APPARATUS

The improved Venturi flume, developed by the division of agricultural engineering for measuring flow in open ditches with a minimum loss of head, now is widely used in the western irrigated States and to some extent in foreign lands. In cooperation with several irrigation companies, a 20-foot flume of this type was built and tested in the Arkansas Valley, with very saitsfactory results, the ca-

pacity exceeding 1,000 second-feet. Plans for a structure with 35-foot throat and a capacity of 1,800 second-feet are now in preparation.

CONTROL OF GRAVEL AND SILT IN IRRIGATION CHANNELS AND RESERVOIRS

In cooperation with the Utah Agricultural Experiment Station, studies of stream action above and below gravel and flood barriers were continued at nine locations. One additional stream, Summit Creek at Santaquin, has been placed under control. The newly completed barrier has eliminated the trouble completely, permitting a complete utilization of the water. A series of checks and equalizers has been built at Garfield in Salt Lake County, Utah, above the plant of the American Smelting & Refining Co., which sustained a loss on June 10, 1927, of over $150,000 through a heavy summer flood which carried bowlders weighing tons through the plant and left a path of destruction in its wake. These control works cost a little under $175,000. Five smaller floods occurred during the course of construction which added considerably to the store of information already available, and tested sections of the work already completed or under way. Another barrier is in process of completion at Mount Pleasant, Utah, which will be finished during 1928. The latter structure offers protection to the town and adjacent farm lands, and if successful, will save the irrigation headworks from washing out each year in midseason.

The study of silt control on the Colorado River was completed in 1926, and a bulletin entitled "Silt in the Colorado River and Its Relation to Irrigation" was issued in 1928. A similar study of streams in Texas, in cooperation with the State board of water engineers, is being continued.

FLOW OF WATER IN DITCHES, PIPES, AND OTHER CONDUITS

A manuscript on the flow of water in metal pipes is nearly completed, and will be submitted before the close of the present fiscal year. Studies are also being carried on concerning flow of water in flumes.

CUSTOMS, REGULATIONS, AND LAWS RELATING TO IRRIGATION

A bulletin has been issued during the fiscal year, dealing with methods adopted by irrigation organizations for the delivery of water and canal management, and a report upon financial settlements of defaulting irrigation enterprises has been prepared. In cooperation with State institutions, irrigation districts that were confronted with unusual financial problems have been studied and reports were made on the Warm Springs, Ochoco and Grants Pass projects in Oregon, and the San Pedro irrigation district in Arizona.

RECLAMATION OF ALKALI LAND

One of the foremost problems encountered in irrigated agriculture is the reclamation of alkali lands. Owing principally to neglect in promptly draining water-logged lands, harmful salts have accumulated in the surface soils of large land areas, which render them useless for agriculture until the salts are removed. Though much land of this character has been reclaimed, failure to do so is common under the condition known as "black alkali." Under cooperative agreement with the agricultural experiment station of Idaho an exhaustive study of the problem has been carried on since 1926 on a 50-acre tract of extremely adverse alkali land. The condition of black alkali soil which is responsible for the slowness in responding to reclamation, has been traced to the mechanical rather than the chemical condition of the soil. The application of chemicals to make the salts more readily soluble, and efforts to make the soil more permeable by blasting, subsoiling, and alternately wetting and drying it, have so far failed to improve the condition. Perhaps economical reclamation of this land will depend upon the production of crops that will compensate the landowner for his efforts, while their root action and chemical action and the leaching effect of irrigation water bring about permanent reclamation. Progress has been made along this line, but the results need verification.

DRAINAGE RUN-OFF FROM IRRIGATED LANDS

Data have been collected from nearly 100 drainage projects, having an aggregate area of about 1,000,000 acres with 2,500 miles of drains, in 13 Western States, showing the maximum discharge per unit of area drained, the maximum discharge per unit of length of drain, the total annual discharge by months, the relation of discharge to irrigation water applied, and as far as possible the factors which influence the rate of discharge. This information will be of value and assistance to drainage-designing engineers and to irrigation

projects which propose to develop part of their supply from drainage works.

IRRIGATION IN HUMID REGIONS

Overhead irrigation for market-garden crops has proven profitable in many localities in the Northeastern States, but this method is too expensive for general farm crops in that region. A study of the practicability of surface irrigation has been started in cooperation with the training school at Vineland, N. J. Measurements of maximum and minimum flow in the creek have been made, and construction of the dam has been begun by the training school. Observations will be made of the frequency and amounts of irrigation, and of the effect upon crop production, comparing the results with crops growing on unirrigated land.

DRAINAGE INVESTIGATIONS

STUDIES OF RUN-OFF AND DITCH CAPACITIES

Determination of the rates at which water collects in the drainage courses during or following storm periods and the sizes of channels necessary to remove the water are fundamental in designing systems of land-drainage improvements. Therefore data have been collected for many years to show the quantities of water flowing from a considerable number of drainage areas, and a great many experiments have been made on the carrying capacities of drainage ditches and natural water courses. The drainage areas vary greatly in size, shape, topography, soil, and surface covering. Such studies have been made in Mississippi, Arkansas, Missouri, Iowa, and Illinois, and in the past year have been begun in northern Indiana. Continuous records have been kept of the flow from each area and of the rainfall over the area, and careful descriptions have been prepared of the various physical features of the areas.

In selected courses of the ditches and natural channels there were made, besides the gaugings of discharge, measurements of the slope of the water surface and of the size, shape, and uniformity of the stream. From these data, values of the empirical coefficients in the Chezy and Kutter formulas have been computed. The experiments include large and small ditches and natural channels, and determinations of flow through standing timber and through sections from which the timber had been cleared in the floodways in Cape Girardeau County, Mo., and Poinsett County, Ark. These data and values, with illustrated descriptions of the channels, have been prepared for publication as a bulletin on the flow of the water in drainage channels.

GROUND-WATER STUDIES

One of the perplexing conditions in studying the drainage of farm lands is the uncertainty in applying the results of investigations in one type of soil to the control of ground water in another type. In too many instances, methods of drainage found effective in one locality have not been satisfactory when used in other localities, for soils that seemingly were similar. The division of agricultural engineering, therefore, has undertaken studies to develop, if possible, a method of determining from fairly simple physical tests how readily any particular soil will respond to underdrainage, and a method of indexing soils according to their drainage characteristics. A great number of soil samples have been collected for analysis from fields where ground-water studies have been made and the drainage requirements are known.

SOIL EROSION INVESTIGATIONS

In cooperation with the agricultural experiment station at Raleigh, N. C., the experiments to determine the rates at which soil is washed from cultivated hillsides by surface water have been continued. Experimental plots on one of the typical soil types have been so arranged that the amounts of water flowing from each plot and the amounts of soil washed off are measured. The plots are cultivated to different crops, in order that not only may the rate of erosion be related to the rainfall and the run-off, but also the effect of different cultural methods retarding or increasing erosion may be studied.

DRAINAGE MATERIALS

Studies relative to the quality of clay draintile for sale in Minnesota are being made in cooperation with the University of Minnesota, and the Minnesota department of drainage and waters. Samples of tile from all the operating clay-tile factories in Minnesota, and from a few in Iowa, were tested for strength, for absorption, and for resistance to freezing and thawing, according to the standards for drain-tile adopted by the American Society for Testing Materials. The correlation

of the results of these experiments makes it possible to determine the resistance to freezing and thawing of any shipment from any of the factories within three days, from tests of strength and absorption only, whereas the freezing and thawing test requires six weeks or more.

In connection with the studies on concrete drain tile, also in cooperation with the same Minnesota agencies, tests have been made on different brands of Portland cement to determine their resistance to the action of water containing sodium sulphate. The results of the tests indicate that more-resistant cements will withstand the action of the salt for three to five times the life of the less-resistant kinds. It appears that in waters having small amounts of sulphates the resistant cements probably will be durable, while the others may fail in a few years. Studies have been undertaken to develop an accelerated test for determining the resistance of Portland cement to action of sulphate waters.

The testing of concrete and mortar specimens in peat soils is being continued. Action of soil chemicals on some of the specimens has been noted, but the tests have not advanced far enough to warrant drawing conclusions.

OPERATION AND MAINTENANCE OF PUMPING PLANTS

Where drainage requires that the water be discharged from the area by pumping, the improvement is much more than ordinarily expensive. Along the Illinois River and along the Mississippi between St. Louis and Savanna, Ill., are more than 60 drainage districts which have about $2,800,000 invested in pumping plants. The annual cost of operating these plants, including fixed charges, is approximately $650,000. Some of the plants are operated by electric motors, the oldest ones by steam power, and many of the newest installations by internal-combustion engines of the Diesel and semi-Diesel types. Because the pumps are not used continuously, but only when the river outside the district is high, most of these districts have considered it uneconomical to employ highly skilled engineers to operate the equipment.

Studies have been carried on for some years, looking to a determination of the conditions under which each kind of power is most economical, and of changes in equipment and methods of operation by which the cost of pumping may be reduced to a minimum. Records of water pumped, of the frequency and duration of the periods of operation, and of the costs of operation were kept on 14 of the pumping plants. Owing to the variations in operating conditions, from year to year as well as between different plants, conclusions as to the limiting conditions for economical use of different kinds of power have not yet been reached. Recommendations made relative to operation, however, usually by changing the speed of the pumps have reduced the power consumption in eight plants by 10 to 33 per cent. A Second Progress Report on the Cost of Pumping for Drainage in the Upper Mississippi Valley During 1925 and a circular, Reduce Cost of Drainage Pumping by Regulating Speeds of Pumps, have been prepared for distribution to drainage engineers, drainage-district officials, and others interested in the subject.

FLOW OF WATER AROUND BENDS AND BRIDGE PIERS

Experiments supplementary to the earlier investigation of the effect of bends in the channel upon loss of head in open channels have been made during the year at the University of Iowa laboratory. Data have been collected also upon the effect of variations in direction and of rapid changes in speed of flow upon the registration of current meters.

A study of the obstruction to flow caused by bridge piers has been undertaken at the hydraulic laboratory of the University of Iowa. Some 360 experiments have been made on pier models with various shapes of noses and tails. Measured losses of head for various quantities of flow have been substituted in well-known pier formulas, and computations have been made of the empirical coefficients. The results indicate that the formulas are not entirely satisfactory, because the coefficient for each shape of pier is not constant for varying velocities of flow. The study of the increase in velocity of flow adjacent to the pier emphasizes the need for protection against scour and undermining.

ORGANIZATION AND DEVELOPMENT OF DRAINAGE DISTRICTS

The development of drainage districts to reclaim large tracts of swamp and overflowed land in the South has been disappointingly slow on the whole. Consequently a large amount of money

has been lost by the promoters, by buyers of the land, and by purchasers of the bonds issued by such enterprises. A report upon the agricultural and financial status of reclamation drainage districts in the Southern States has been prepared from the results of an investigation made in cooperation with the Bureau of Agricultural Economics.

CORN BORER CONTROL

The division of agricultural engineering has had charge of the mechanical equipment used by the Government in combating the European corn borer, and has made intensive studies of the design and use of such equipment for the work. In collaboration with entomologists of the department, tests have been made in badly infested fields of the efficiency of silage harvesters and stubble pulverizers in killing the borers, and of the performance of low-cutting corn binders. In cooperation with manufacturers of the machines, certain improvements made or suggested have been embodied in later models and have increased the effectiveness of the machines.

Studies have been made in cooperation with the entomologists to determine the temperature and period of exposure necessary to destroy the borers in the stalks, and the conditions influencing the effectiveness of burning. Various types of burners have been tested, and experiments have been made with burner carriages and with hoods for confining the flame in high winds. Simultaneously, pump-performance tests were made, and tests of friction losses in high-pressure hose of different diameters, length, discharge rates, and pump pressures, the fluid being the fuel oils used in the burners. Soil conditions in the spring prevent the use of very heavy machinery, thus increasing the difficulty of devising a practical burner.

A thorough study has been made of plows and p owing attachments for use in fighting the corn borer and of treatment of the fields before and after plowing to secure best results. Plows with wide bottoms were found most effective in covering the stalks, partly because of greater clearance and more room to adjust large coulters and jointers. Single-bottom plows gave somewhat better results than those with two or three bottoms. Disking or chopping standing stalks was found, in most cases, to be detrimental rather than helpful for clean plowing.

FARM STRUCTURES

Growers of sweet potatoes in tidewater Virginia and neighboring States ordinarily suffer considerable losses while the crops are in storage. Field studies were made, in cooperation with the Virginia Polytechnic Institute and the Virginia Truck Experiment Station at Norfolk, to determine the proper method of handling sweet-potato storage houses in order to hold the potatoes in good condition for marketing. The report of this investigation has been completed.

From studies made in Maine, a report on the requirements for, and construction of potato-storage houses has been prepared, the information to be applicable also in other northern potato-growing regions.

FARM MECHANICAL EQUIPMENT

COTTON-DUSTING MACHINERY

The experiments and tests of equipment for applying insecticides to cotton plants are being continued at Tallulah, La., in cooperation with the Bureau of Entomology as heretofore. Progress has been made in selecting and developing more effective machines and devices for this work, both horse-drawn equipment and for dusting the fields from airplanes. The work was interrupted for a time in 1927, owing to flooding of the experiment station from crevasses in the Mississippi levees.

COTTON-HARVESTING MACHINERY

One of the most laborious and costly operations in producing cotton has been that of harvesting the crop. Many times a considerable part of the crop has been lost for lack of labor to gather it. A great many mechanical devices for doing this work have been attempted by farm-machinery manufacturers, most of which have not been perfected to a practicable degree. During 1927, a study of equipment and methods, other than hand methods, being used or tried in northwestern Texas, was made by the division of agricultural engineering in cooperation with the State agricultural experiment station. Various kinds of strippers were examined, from simple homemade sleds to rather elaborate machines developed by large manufacturers, and the results obtained with the equipment under different conditions were noted and compared. The strippers gather the bolls and more or less trash with the seed cotton, which add to the

cost of ginning if not removed before being taken to the gin. Machinery for extracting the bolls and cleaning the cotton on the farm was studied.

Where the cotton plants grow large and the bolls ripen unevenly, stripping is not practicable, and for such conditions mechanical pickers with revolving spindles have been made. These are operated by tractors, and are expensive. They have not yet been developed to the point where their use is practicable under all conditions.

The results of this study have been prepared for publication by the Texas Agricultural Experiment Station.

COTTON-DRYING EQUIPMENT

Seed cotton as harvested many times is sufficiently damp to cause injury to the lint in ginning and to impair the planting and milling qualities of the seed. Present practice in cotton production is to have the crop ginned as rapidly as it is harvested without drying. For investigating the practicability of artificial drying, studies were made to determine the ordinary and the desirable moisture contents of seed cotton brought to gins, which indicated that 2½ to 5 per cent of the weight of the raw cotton should be removed before ginning.

Five different types of small units for artificial drying of seed cotton were constructed and tested, and a full-sized unit was constructed at Transylvania, La., having a capacity of 2 tons of seed cotton or 2 bales of lint cotton, per hour. Removal of moisture was secured by forcing heated air three times through a continuously moving layer of the cotton. The results of drying approximately 60 bales in the 1927 ginning season showed most of the dried cotton to have a value of one-half to 3 cents per pound over similar cotton ginned without drying. The cost of drying, under ordinary industrial conditions was indicated as about $1 or less per bale.

Three public patents on the equipment and processes developed in this study have been applied for through the Department of Agriculture.

FERTILIZER DISTRIBUTORS

The economical use of fertilizers requires that they be distributed uniformly to the plants, and at a predetermined rate. It has been observed that present types of mechanical distributors, in general, give neither uniform distribution nor constant rates of delivery. In cooperation with the Bureau of Chemistry and Soils, investigation has been made of the properties of the fertilizers and the characteristics of the distributors which affect the results. Study was made of the effect of such factors as the size of the particles of fertilizer, the shape of the particles, the amount and kind of conditioners used, the homogeneity of the material, and the humidity of the atmosphere, and also of the various mechanical principles and devices used for delivering the fertilizer from the hopper of the machine to the drills, of imperfections in the mechanical parts, of inaccuracies in adjustments, and of carelessness in operating the machines. The results are being prepared for publication for the benefit of manufacturers both of fertilizers and distributors, and of those who use the fertilizers in growing crops.

RESEARCH IN MECHANICAL FARM EQUIPMENT

The survey of the status of research in mechanical farm equipment begun about two years ago at the request of the National Association of Farm Equipment Manufacturers and the American Society of Agricultural Engineers, was completed. The final report, summarizing the present state of research in this field and containing suggestions for future procedure has been submitted for publication.

COMBINED HARVESTER-THRESHER STUDIES

Introduction of the combined harvester-thresher for harvesting wheat in the Great Plains States is causing marked changes in the harvesting methods there, and increasing use of those machines in other States apparently will cause like changes in more eastern regions. During the year there was published (Technical Bulletin No. 70) the result of the studies on the use of these machines made in Texas, Oklahoma, Kansas, Nebraska, and Montana, in cooperation with the Bureau of Agricultural Economics, the Bureau of Plant Industry, and the State agricultural experiment stations. Particular consideration was given by the agricultural engineers to the mechanical features of design and the manner of operation, for reducing costs of operation and repairs, and losses of grain in harvesting and threshing. Similar studies have subsequently been made in Illinois, Indiana, Pennsylvania, and Virginia, especially relative to the use of the harvester-thresher for soy beans and grain sorghums. A manuscript for a bulletin on the care and opera-

tion of the combine-harvester is in preparation.

TRANSPORTATION OF PERISHABLE PRODUCTS

Results of experiments made prior to 1927, in cooperation with the Bureau of Plant Industry, upon the insulation of refrigerator cars and the effect of moisture on thermal conductivity of the materials, and upon the value of body icing for various vegetables, have been prepared. Experiments have been made in heating and ventilating cars carrying winter shipments of products from the Pacific Northwest to eastern markets, and tests of various heaters for this purpose have been made. The effects of different methods of preparing and loading the cars have been studied, relative to uniformity of distribution of the heat and control of temperature. Valuable information has been obtained, but the tests will be continued in order to secure more certain results.

WAR-SURPLUS EXPLOSIVES FOR AGRICULTURAL USE

The final shipments of pyrotol, for agricultural use, were made in April, 1928. Pyrotol was the last of three explosives that have been available to the farmers since 1921, the others being picric acid and sodatol. Pyrotol was the name given to an explosive which was worked out experimentally in the endeavor to make use of a large quantity of smokeless powder turned over as surplus by the War Department. It was composed of smokeless powder (60 per cent), sodium nitrate (34 per cent), and a sensitizer (6 per cent). The materials were assembled, mixed, cartridged, and shipped under a contract awarded to E. I. du Pont de Nemours (Inc.). This work was done at three points—Gibbstown, N. J., Barksdale, Wis., and Du Pont, Wash. Carload shipments were made from these points on orders of the State agencies cooperating in this enterprise. As in the case of the other explosives, the cost to the farmer, at the plant, was only that of preparing and shipping and amounted to 6 cents per pound from the Gibbstown and Barksdale plants and 5.6 cents per pound from the Du Pont plant.

Pyrotol proved to be an excellent stumping explosive—perhaps the best of the three explosives distributed. Bulk for bulk, it was approximately equal in strength to 40 per cent dynamite. It was comparatively safe, and it did not stain or cause headache or other ill effects when handled. Table 23 shows by States the quantity of pyrotol distributed for agricultural use during the fiscal year 1928 and the totals of all war surplus explosives distributed for such use.

TABLE 23.—*Shipments of pyrotol, 1928, and of all explosives, 1922–1928, inclusive*

State	Pyrotol, fiscal year 1928	All explosives, fiscal years 1922–1928
	Pounds	*Pounds*
Alabama	153,700	803,900
Alaska	----------	5,500
Arizona	----------	1,300
Arkansas	16,000	99,400
California	74,000	400,400
Colorado	----------	150
Connecticut	----------	94,400
Florida	----------	37,000
Georgia	153,300	436,400
Hawaii	----------	1,000
Idaho	250,000	1,758,900
Illinois	23,000	119,200
Indiana	50,000	252,500
Iowa	265,000	1,568,150
Kansas	----------	17,800
Kentucky	----------	71,150
Louisiana	20,000	151,900
Maryland	1,000	14,750
Michigan	584,550	5,813,650
Minnesota	1,336,550	10,568,700
Mississippi	32,000	200,050
Missouri	116,000	675,800
Montana	100,000	736,100
Nebraska	86,100	473,650
New Jersey	----------	4,200
New Mexico	----------	500
New York	----------	66,450
North Carolina	577,350	3,690,250
Ohio	32,200	252,200
Oklahoma	----------	400
Oregon	927,500	5,707,950
Pennsylvania	32,000	123,600
South Carolina	210,550	938,700
South Dakota	81,500	381,500
Tennessee	13,650	302,750
Texas	52,050	258,300
Vermont	----------	5,800
Virginia	106,500	491,350
Washington	1,579,900	10,128,800
West Virginia	36,000	68,250
Wisconsin	1,200,000	16,968,450
Experimental	----------	2,400
Total	8,110,400	63,693,600

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., September 1, 1929.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1929, covering the work done in connection with the construction of Federal-aid, national-forest, and national-park roads, the economic and physical researches in connection with problems of highway improvement, and the research and other work of the division of agricultural engineering.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

For several years the appropriations authorized for Federal aid in the improvement of the Federal-aid highway system have been $75,000,000 a year. Owing to the fact that the appropriations for the earlier years were not expended within the years for which they were made a balance had been accumulated which has permitted in recent years a rate of improvement greater than would have been possible within the appropriations authorized. This balance has now been absorbed and it has been necessary to confine the program of improvement within the limitations of the appropriations currently authorized.

Accordingly the mileage of improvements completed during the fiscal year 1929 was smaller than in previous years. Initial improvements were completed during the year on only 7,402 miles of the system as compared with 8,184 miles the preceding year. Advanced stages of improvement were completed on 1,987 miles, less by 27 miles than the mileage of similar improvements during the fiscal year 1928. At the close of the year initial improvements were in progress on approximately 8,358 miles and advanced stage construction was under way on 1,167 miles, the corresponding figures a year ago being 9,494 and 1,285 miles, respectively.

All of this work was and is being done on roads included in the Federal-aid highway system which, on June 30 of this year consisted of 188,857 miles of main interstate and intercounty roads.

The total mileage initially improved with Federal aid since the beginning of Federal cooperation is 79,796 miles. Of this mileage a portion, improved prior to 1921, was not included in the Federal-aid system designated in accordance with the Federal highway act passed in that year. In general, the roads omitted from the system were not of sufficient importance to justify inclusion, but having received Federal aid for their improvement the State highway departments have been required by the law to maintain them.

In order to free the States of the necessity of continuing the maintenance of these relatively unimportant roads, arrangements have been made whereby the roads of this character may be abandoned as Federal-aid highways and the Federal funds ex-

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pended for their improvement refunded to be reallotted to current projects within the designated system. During the past year approximately 485 miles of such roads have been abandoned, thereby reducing the initially improved mileage of record to 79,311 miles.

By relocations made in the course of stage construction the original length of the improved roads has been reduced by a total of nearly 47 miles, so that the actual present length of the roads initially improved with Federal aid and retained as Federal-aid highways is 79,264 miles. As approximately 1,167 miles were undergoing stage construction at the close of the year and had accordingly been temporarily removed from the classification of improved mileage, the total so classified on June 30, 1929, was 78,096.6 miles.

In addition to the cooperative work carried on under the Federal-aid appropriation, the bureau has also cooperated with the States of Vermont, New Hampshire, Kentucky, Missouri, Arkansas, Louisiana, and Mississippi in the restoration of roads damaged or destroyed by the floods of 1927. This work has been done under special flood-relief legislation enacted by the last Congress; and has resulted so far in the completion of improvements on 21 miles of road in Vermont, 14 miles in New Hampshire, and 29 miles in Kentucky. Other improvements are under way in these States and in the States of the Mississippi Valley above mentioned.

By the completion of 315.4 miles of national-forest roads during the year the total mileage upon which improvements have been completed is increased to 4,090.7. Of this total, 3,782 miles are in the 12 Western States and the Territory of Alaska and 308.7 miles are in Eastern States. These improved roads are portions of the forest road system which has been designated jointly by State and Federal authorities and which includes at present a total of 14,165.7 miles of which 12,014.5 miles are in the 12 Western States and Alaska, and the balance in eastern States.

The work done in improvement of national-park roads under agreement with the National Park Service resulted during the year in the completion of 100.7 miles of important improvements in these reservations including the interesting tunnel section of the Zion Park project and the west-side section of the famous Transmountain Highway in Glacier Park. By the year's addition the mileage of completed improvements in the national parks is brought to 213.4 miles, almost doubling the mileage previously improved. At the close of the year construction was in progress on 113 miles and surveys were under way on 209 miles. All this work is directed toward the eventual improvement of a system of major park roads including 1,509.7 miles.

Among the numerous investigations conducted by the bureau with a view to improving the design of highways and the quality of highway materials, none has produced this year more encouraging results than the studies of soils with respect to their behavior as road subgrades. By the various tests that have been developed it is now believed to be possible to classify the majority of soils encountered in road construction and anticipate their behavior under the conditions to which they are subject as road subgrades; and a report has been issued during the year which outlines definite methods of utilizing this knowledge as a guide in the design of pavements and other road surfaces to be laid on the various types of soil.

Investigations and methods of constructing low-cost bituminous roads are being continued, and information of great value is being obtained and applied in the improvement of portions of the Federal-aid system subject to fairly light traffic and by State and local authorities to other roads of like character outside of the Federal system.

Other physical investigations, especially those relating to the character of Portland cement concrete and the effect of various elements on its quality, have produced important results that have been disseminated in the bureau's publication, Public Roads.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

Initial improvements were completed during the year on 7,402.3 miles of the Federal-aid highway system. Advanced stages of construction were completed on 1,987.7 miles. The total mileage upon which improvements were completed was therefore 9,390 miles.

At the close of the year construction of initial improvement was in progress on 8,358.6 miles, and other initial improvements had been approved for 1,833 miles. Stage construction was

in progress at the close of the year on 1,167.7 miles of road already initially improved with Federal aid, and similar advanced improvements had been approved for 1,065.3 miles.

The year's completion of initial improvements was less than that of any year since 1921 and less than that of the preceding year by 782 miles. The mileage of stage construction completed was greater than the mileage completed in any previous year except 1928, and was less than the record of that year by only about 27 miles. In respect to the total mileage of improvement completed, the year's record was lower than that of all years since 1921 with the exception of 1923 and 1924. The record of mileage completed in each of the fiscal years since 1921 is shown in Table 1.

The decline in mileage completed during the last year is the anticipated result of the shrinkage of the program to the rate fixed by the appropriations of $75,000,000 which have been made for several years past and the absorption of unobligated balance passed on from the earlier years of operation.

TABLE 1.—*Mileage of initial and stage construction completed, by fiscal years, 1917–1921 to 1929, inclusive*

Fiscal year	Mileage of initial construction completed	Stage construction completed		Total construction
		Mileage	Percentage of initial construction	
				Miles
1917–1921	7,469.5	----------	----------	7,469.5
1922	10,247.0	----------	----------	10,247.0
1923	8,820.2	117.8	1.3	8,938.0
1924	8,620.3	360.4	4.2	8,980.7
1925	11,328.6	556.4	4.9	11,885.0
1926	9,417.3	1,052.6	11.2	10,469.9
1927	8,306.9	1,712.6	20.6	10,019.5
1928	8,184.2	2,014.1	24.6	10,198.3
1929	7,402.3	1,987.7	26.9	9,390.0

A year ago the total mileage upon which initial improvements had been completed was 72,394 miles. Up to that time relocations made in the course of stage construction had resulted in the shortening of the original mileage by 34.5 miles, so that the reduced mileage of completed initial improvements was 72,359.5 miles.

During the past year relocations have been completed in the course of stage construction which further reduce the original mileage by 12.2 miles and 485.3 miles improved with Federal aid prior to 1921 and not included in the Federal-aid highway system have been abandoned, as explained subsequently in this report. With these reductions, the addition of 7,402.3 miles of completed initial improvements during the year brings the total of such initial improvements to 79,264.3 miles. With the exception of a small mileage, improved prior to 1921 and still retained, all of this mileage is in the Federal-aid highway system. As 1,167.7 miles of the above total was in course of stage construction when the fiscal year closed, the total mileage classified as improved at that time was 78,096.6, as shown in Tables 16 and 20.

The Federal-aid system, as designated to June 30, 1929, includes 188,857.2 miles of main interstate and intercounty highways. As indicated above, approximately 79,000 miles of the system have been initially improved thus far with Federal aid. While these improvements have been under way with Federal aid the States have been improving other sections without assistance from the Federal Government and their independent work has equalled and perhaps exceeded in volume the work done in cooperation with the Government. A portion of the system was already improved when it was originally designated in 1921. Of the amount of this original improvement and the amount subsequently effected by the independent operations of the States there is no exact record, but a log of the physical condition of the system compiled after inspection of the entire mileage shows that nearly 90 per cent of the system has now been improved to some degree, at least by adequate grading and drainage.

STAGE CONSTRUCTION

As shown by Table 1, stage construction was completed during the year on 1,987.7 miles of the system previously improved with Federal aid. Although this was less than the mileage similarly improved in the preceding year by 26.4 miles, the stage construction this year constituted a greater part of the whole program than in any previous year. Again referring to Table 1, it will be seen that the mileage of stage construction completed this year was 26.9 per cent of the mileage of

initial improvement completed; and it will also be observed that the corresponding percentage has increased progressively year by year since the first work of this sort was done in the fiscal year 1923. As the improvement of the system progresses toward the condition ultimately required it is to be expected that this percentage will continue to increase.

The log of physical condition recently completed indicates that there are now only about 20,000 miles that have not been improved at least by adequate grading and drainage. If the combined efforts of the States and the Federal Government were applied to this unimproved mileage only, it would all be improved in a year or two. It is not likely that this will be done because of the greater need for advanced improvement on other sections of the system. Consequently, there will probably remain for several years some small unimproved sections of the system—the least important of all parts of the system from the standpoint of traffic service.

It does not follow, however, from the fact that substantially the entire system is now or will shortly be improved to some degree, that all Federal-aid work will soon be classed as stage construction. The work so classified includes only the advanced stages of construction on sections of the system originally improved with Federal aid. The first work done with Federal aid on any section of the system is classed by the bureau as initial construction, whether it consist merely of grading and drainage or the construction of a surfaced or paved road. Consequently there is now classified as initially improved with Federal aid a considerable mileage which had been improved by the States to some degree before the first Federal-aid work was done upon it. By virtue of the definition of "initial improvement," as used in these reports, it is to be expected that work so classified will remain for some time an important part of the Federal-aid activity, but it is also to be expected that the type of construction so classified will be higher in the future than it has been in the past.

Since the stage construction is applied to mileage already initially improved with Federal aid it does not increase the initially improved mileage; but, on the contrary, may result in a slight reduction of the original mileage by reason of distance-shortening relocations of alignment. The work of stage construction completed this year, as previously indicated, effects such a reduction amounting to 12.2 miles.

The purpose of the stage construction and its invariable effect is gradually to raise the standard of the roads improved with Federal aid. Because of the pressure of traffic demand and the lack of sufficient funds to improve all parts of the system at once to the standard ultimately required, it has been necessary to limit the initial improvement of the more lightly traveled sections of the system to grading and drainage or to the construction of an inexpensive surface in order to give some measure of improvement to as large a mileage as practicable. As increasing traffic demands and available funds permit these cheaply improved sections are further improved by stage construction, involving usually the construction of a surface where none was built originally or the replacement of a low-type original surface with one of higher type. Occasionally the work involves the correction of alignment or the elimination of railroad grade crossings either by construction of a grade-separating structure or by relocation of the highway to avoid the crossing. In one way or another the effect is gradually to better the existing improvement and this effect is most clearly apparent by comparing the type classification of the improved mileage from year to year.

A year ago, for example, the mileage improved with high-type pavements of brick, concrete, and bituminous concrete was less than 29 per cent of the total improved mileage. Two years prior to that the corresponding percentage was less than 26. To-day 30.4 per cent of the mileage classified as improved (exclusive of bridges) is paved with these highest types of surfacing.

As will be observed in Table 2, 51 per cent of the mileage of stage construction completed during the year was in the West North Central States. Less than 4 per cent was in the sections of the country where population is most dense and traffic heaviest, including the New England, Middle Atlantic, East North Central, and Pacific groups of States. The rest is in the Southern States and the area west of the Mississippi River, mostly in the latter section.

Two factors combine to produce this result: (1) The relative urgency of high-type improvement, and the availability of funds for the purpose; and (2) the extent to which the roads of the various sections had been initially improved without Federal assistance before the designation of the system. Thus, in the sections where traffic is heaviest there has existed for some years an urgent need for road improvement of an advanced type and revenue has been available to carry out such improvement at a reasonable rate. In these sections improvement had been in progress for a considerable period prior to the designation of the Federal-aid system, and a comparatively large percentage of the mileage designated had already been improved to some extent, at least by grading and drainage. The initial Federal-aid improvements in these sections have therefore been of a comparatively high type, and there has been little need to raise their standard by stage construction.

TABLE 2.—*Mileage of stage construction completed during the fiscal year 1929, by groups of States*

Group of States	Mileage of stage construction completed during the year	Percentage of the total
New England	0.3	
Middle Atlantic	8.5	0.4
South Atlantic	182.1	9.2
East North Central	51.7	2.6
East South Central	217.7	11.0
West North Central	1,014.4	51.0
West South Central	241.2	12.1
Mountain	257.5	13.0
Pacific	14.3	.7
All States	1,987.7	100.0

In the other sections, particularly in the region between the Mississippi and the western tier of States, many of the States had made but little progress in road improvement before the Federal-aid system was designated. Traffic at that time was relatively light, and the funds available for construction were, in some cases, extremely limited. With so much of the system entirely unimproved, the first effort was directed toward the extension of some measure of betterment to a large mileage as quickly as possible. Then, as traffic increased, these original improvements have been brought to higher type. In these regions the Federal Government has assisted in the original improvements and is now cooperating in their advancement to higher type; and as would naturally be expected, the advanced improvements constitute the highest percentage of the whole program in the States where the traffic demand is greatest and where there is the nearest approach to completion of the initial improvement of the system. This is preeminently the case in the West North Central States and accounts for the high percentage of the stage construction work that has been done in recent years in this section.

ABANDONMENT OF MILEAGE OUTSIDE OF FEDERAL-AID SYSTEM

Prior to the passage of the Federal highway act in 1921 the law permitted the expenditure of Federal aid upon any road used for the transportation of the United States mails. Although the bureau had requested the States to confine the use of the Federal grants to the improvement of the more important roads, there was no legal means of compelling such a limitation, and some of the money was expended for the improvement of sections of road which were not of sufficient importance to be included in the Federal-aid system when it was designated.

In accordance with the provisions of the Federal law, the States in which such sections existed have since been required to maintain these as well as all other roads constructed in part with Federal aid. None of these sections of road is of sufficient importance to be properly a concern of the Federal Government, and many of them do not justify the attention of the State highway departments. They are actually of local importance and should revert to the jurisdiction of the local authorities.

In recognition of this fact there has been begun a process of abandonment by which in a short time all such roads and sections of roads not now included in the Federal-aid system or likely to be included by any future extension will be dropped from the records of roads built with Federal aid, and the States will be relieved of the responsibility for their future maintenance.

The Federal aid allotted to the construction of these roads is being

charged to other projects currently proposed at the time of abandonment. Thus, in effect—although no actual transfer of funds is required—the States reimburse the Federal Government in the amount of its expenditures upon the roads to be abandoned, and the restored funds are immediately allotted to other projects.

Up to the close of the fiscal year there had been thus abandoned in 18 States 485.3 miles of road, originally constructed at a total cost of $4,734,059.24, of which the Federal Government paid $1,906,542.61. The States in which these roads were abandoned and the mileage, total cost, and Federal aid involved in each State, are shown in Table 3. The mileage of the several types of road abandoned in each of the States is given in Table 4. As will be seen from this table, the greater part of the abandoned mileage had been improved with low-type surfaces.

TABLE 3.—*Total cost, Federal-aid, and mileage of roads abandoned to June 30, 1929, for which other improvements have been substituted*

State	Total cost	Federal aid	Mileage
Alabama	$33,947.60	$16,433.17	5.5
Arkansas	369,863.37	163,645.40	35.2
Kansas	3,084.76	1,542.38	1.5
Louisiana	31,433.22	14,301.06	1.1
Massachusetts	12,150.10	6,075.05	.1
Michigan	357,020.74	163,618.76	20.9
Minnesota	1,319,394.61	491,282.38	178.4
Montana	783.93	391.96	.2
Nebraska	293.68	146.84	.2
Nevada	10,046.35	5,023.17	
New Mexico	52,715.38	25,964.81	9.9
New York	43,692.89	18,245.34	1.1
North Dakota	42,372.46	20,968.87	7.1
South Carolina	4,779.96	2,294.32	
Texas	99,290.75	33,333.34	7.4
Virginia	236,358.30	99,198.03	8.9
Wisconsin	2,104,922.58	838,916.92	197.4
Wyoming	11,908.56	5,160.81	10.4
Total	4,734,059.24	1,906,542.61	485.3

TABLE 4.—*Mileage of roads abandoned to June 30, 1929, for which other improvements have been substituted, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Bridges	Total
Alabama			5.5						5.5
Arkansas			32.0		3.0		0.1	0.1	35.2
Kansas	1.5								1.5
Louisiana			1.1						1.1
Massachusetts								.1	.1
Michigan			14.4	2.6		3.9			20.9
Minnesota	17.2		155.7				5.5		178.4
Montana	.1		.1						.2
Nebraska	.2								.2
Nevada									
New Mexico			9.9						9.9
New York							1.1		1.1
North Dakota	6.8							.3	7.1
South Carolina									
Texas			7.4						7.4
Virginia				1.4	7.5				8.9
Wisconsin	49.5	28.5	100.6				18.7	.1	197.4
Wyoming	10.4								10.4
Total	85.7	28.5	326.7	4.0	10.5	3.9	25.4	.6	485.3

The status and character of the new projects upon which the refunded Federal aid has been reallotted are reported fully in Tables 5, 6, 7, 8, 9, and 10. It is shown in these tables that $1,467,699.15 of the refunded total has been allotted, together with additional Federal funds in the amount of $1,746,041.23, as Federal aid in the construction of 198.6 miles of initial improvement and 42.3 miles of stage construction that was completed by the end of the fiscal year at an estimated total cost of $7,867,888.21. These new improvements are shown by Tables 6 and 7 to be predominantly of the higher types. The balance of the Federal expenditure returned, amounting to $438,843.46, has been reallotted in conjunction with an additional sum of $1,452,460.09 to 153.7 miles of initial improvement and 7.6 miles of stage construction which at the close of the year was still under construction. The estimated total cost of these projects, as shown in Table 8, is $4,081,922.16. Their type classification is shown in Table 9.

TABLE 5.—*Total cost, Federal aid substituted, additional Federal aid allotted, and initial and stage mileage of substituted improvements completed to June 30, 1929*

State	Estimated total cost	Federal aid substituted	Additional Federal aid allotted	Mileage	
				Initial	Stage
Arkansas	$1,329,227.26	$54,178.30	$601,174.42	23.1	
Michigan	157,819.35	13,800.15	58,940.85	3.8	
Minnesota	1,974,882.84	491,282.38	74,082.43	40.4	6.6
Montana	26,261.68	92.64	11,179.68	2.0	
New York	425,000.00	18,245.34	125,355.00	9.5	
North Dakota	33,795.54	16,575.23		9.4	
Texas	451,779.61	33,333.34	179,177.28		18.1
Virginia	348,235.08	89,031.06		7.1	
Wisconsin	3,102,728.26	745,999.90	696,131.57	103.3	7.8
Wyoming	18,158.59	5,160.81			9.8
Total	7,867,888.21	1,467,699.15	1,746,041.23	198.6	42.3

TABLE 6.—*Mileage of completed initial improvements substituted for abandoned roads to June 30, 1929, by types of construction, by States*

State	Graded and drained	Gravel	Water-bound macadam	Bitu-minous macadam	Portland cement concrete	Bridges	Total
Arkansas	3.9				18.3	0.9	23.1
Michigan					3.8		3.8
Minnesota	7.6				32.8		40.4
Montana		1.8			.2		2.0
New York					9.5		9.5
North Dakota	9.4						9.4
Virginia				7.1			7.1
Wisconsin		22.6	4.0		76.5	.2	103.3
Total	20.9	24.4	4.0	7.1	141.1	1.1	198.6

TABLE 7.—*Mileage of completed stage improvements substituted for abandoned roads to June 30, 1929, by types of construction, by States*

State	Graded and drained	Gravel	Portland cement concrete	Total
Minnesota	6.6			6.6
Texas			18.1	18.1
Wisconsin			7.8	7.8
Wyoming		9.8		9.8
Total	6.6	9.8	25.9	42.3

TABLE 8.—*Total cost, Federal aid substituted, additional Federal aid allotted, and initial and stage mileage of substituted improvements under construction on June 30, 1929*

State	Under construction				
	Estimated total cost	Federal aid substituted	Additional Federal aid allotted	Mileage	
				Initial	Stage
Alabama	$177,438.51	$16,433.17	$72,286.08	16.6	
Arkansas	349,232.26	109,467.10	65,149.03	15.4	
Kansas	78,417.02	1,542.38	19,844.08	11.1	
Louisiana	876,678.13	14,301.06	424,038.00	3.6	
Massachusetts	245,104.53	6,075.05	69,410.72	4.8	
Michigan	762,940.86	149,818.61	186,921.39	23.5	
Montana	201,469.62	299.32	113,732.48	16.6	
Nebraska	5,557.42	146.84	2,631.87	.9	
Nevada	43,746.45	5,023.17	33,845.54	6.3	
New Mexico	248,008.86	25,964.81	131,735.75	7.8	
North Dakota	124,287.92	4,393.64	49,494.35	23.6	
South Carolina	254,973.03	2,294.32	45,000.00		7.6
Virginia	123,398.35	10,166.97	47,293.82	3.7	
Wisconsin	590,669.20	92,917.02	191,076.98	19.8	
Total	4,081,922.16	438,843.46	1,452,460.09	153.7	7.6

TABLE 9.—*Mileage of initial improvement under construction on June 30, 1929, substituted for abandoned roads, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Bituminous macadam	Bituminous concrete	Portland cement concrete	Bridges	Total
Alabama	16.5						0.1	16.6
Arkansas						15.4		15.4
Kansas	11.0						.1	11.1
Louisiana							3.6	3.6
Massachusetts				4.8				4.8
Michigan			3.0			20.5		23.5
Montana			16.6					16.6
Nebraska		0.9						.9
Nevada				6.3				6.3
New Mexico			4.0		2.9	.4	.5	7.8
North Dakota	23.5						.1	23.6
Virginia				3.7				3.7
Wisconsin			3.9			15.6	.3	19.8
Total	51.0	.9	27.5	14.8	2.9	51.9	4.7	153.7

NOTE.—The only mileage of stage improvement under construction on June 30, 1929, substituted for abandoned roads is 7.6 miles of Portland cement concrete in South Carolina.

TABLE 10.—*Comparison of the abandoned and substituted mileages on June 30, 1929, by States*

State	Abandoned	Substituted	Changes in the mileage of roads improved with Federal aid	
			Increase	Decrease
Alabama	5.5	16.6	11.1	
Arkansas	35.2	38.5	3.3	
Kansas	1.5	11.1	9.6	
Louisiana	1.1	3.6	2.5	
Massachusetts	.1	4.8	4.7	
Michigan	20.9	27.3	6.4	
Minnesota	178.4	40.4		138.0
Montana	.2	18.6	18.4	
Nebraska	.2	.9	.7	
Nevada	(1)	6.3	6.3	
New Mexico	9.9	7.8		2.1
New York	1.1	9.5	8.4	
North Dakota	7.1	33.0	25.9	
South Carolina	(1)	(2)		
Texas	7.4	(2)		7.4
Virginia	8.9	10.8	1.9	
Wisconsin	197.4	123.1		74.3
Wyoming	10.4	(2)		10.4
Total	485.3	352.3	99.2	232.2

[1] Less than 0.1 mile.

[2] Stage improvement substituted.

TYPES OF FEDERAL-AID ROADS

The 7,402.3 miles of initial improvement completed during the year consists of 2,198.1 miles of graded and drained earth roads, 478.5 miles of sand-clay roads, 1,755.5 miles of gravel roads, 85 miles of water-bound macadam roads, 380.8 miles of bituminous macadam roads, 132 miles of bituminous concrete pavement, 2,284.9 miles of concrete pavement, and 43.9 miles paved with brick. The remaining 43.6 miles were made up of numerous bridges and their approaches, each structure more than 20 feet in length.

If the ratio of registered motor vehicles in each State to the mileage of the Federal-aid highway system be taken as a rough measure of the general density of traffic on the system, it will be seen from Table 11 that the types of improvement completed during the year are generally consistent with the density of traffic in each geographic subdivision of the United States, with the exception of the Pacific States. In this table it is

shown that the higher types, including the pavements and bituminous macadam, which are the types best suited to heavy and dense traffic, are represented in greatest proportion in the mileage completed in the Middle Atlantic States where traffic is heaviest; and that the proportion of these types in other divisions, with the exception of the Pacific group, is roughly consistent with the traffic factor.

TABLE 11.—*Relation of the types of initial improvements completed during the fiscal year 1929 and the general density of motor-vehicle traffic on the Federal-aid highway system, by groups of States*

Group of States	Number of motor vehicles per mile of Federal-aid system [1]	Percentage of mileage of initial improvements completed	
		Bituminous macadam and higher types	Waterbound macadam and lower types
Middle Atlantic	384	87.3	12.7
New England	255	80.8	19.2
Pacific	220	43.3	56.7
East North Central	214	78.2	21.8
South Atlantic	103	63.7	36.3
West South Central	89	35.4	64.6
East South Central	79	24.0	76.0
West North Central	70	14.0	86.0
Mountain	39	13.0	87.0
All States	129	38.8	61.2

[1] As registered in the several States during the calendar year 1928.

While in the initial improvements completed during the year the pavement types and bituminous macadam constituted only 38.8 per cent of the total, the net increase of these types, as indicated by Table 27, was 55.6 per cent of the total net increase in mileage, exclusive of bridges, during the year. The difference here noted is the combined effect of stage construction and the substitution of higher types of improvement for the abandoned improvements outside of the Federal-aid system.

As shown by Table 12, the net increase in the mileage of Portland cement concrete pavements was greater than the increase of any other type of improvement; and this table also shows that the increase of the four higher types of improvement was 15.7 per cent as compared with 6.7 per cent for the four lower types, and a general increase of 9.9 per cent.

Of the 78,096.6 miles classified as improved with Federal aid at the close of the year, 11,667.6 miles were graded and drained earth roads, 7,033.3 miles were sand-clay roads, 28,991.1 miles were gravel roads, 1,615.7 miles were water-bound macadam roads, 4,844.8 miles were bituminous macadam roads, 2,193.8 miles were paved with bituminous concrete, 20,617.6 miles were Portland cement concrete pavements, and 865.8 were paved with brick and other block. The remaining 266.9 miles consisted of bridges, each over 20 feet in span, and their approaches.

TABLE 12.—*Mileage of the several types of Federal-aid roads improved at the close of the fiscal years 1928 and 1929 and percentage of increase*

Type	Mileage at close of fiscal year		Percentage increase during fiscal year 1929	
	1928 [1]	1929 [1]		
Graded and drained	10,611.3	11,667.6	9.9	
Sand-clay	6,470.9	7,033.3	8.7	6.7
Gravel	27,698.3	28,991.1	4.7	
Water-bound macadam	1,426.6	1,615.7	13.2	
Bituminous macadam	4,317.2	4,844.8	12.2	
Bituminous concrete	1,993.3	2,193.8	10.0	
Portland cement concrete	17,516.3	20,617.6	17.7	15.7
Brick	817.9	865.8	5.9	
Total	70,851.8	77,829.7	9.9	

[1] Mileage under stage construction at the close of the year and reduction in mileage by relocation, abandonments, etc., deducted from total mileage completed.

EFFECT OF INCREASED TRAFFIC ON ROAD DESIGN

Ten years ago the total number of motor vehicles registered in the United States was approximately 7,500,000. To-day the number in use exceeds 25,000,000, and the number registered in the four States of New York, California, Ohio, and Pennsylvania practically equals the registration in the entire country in 1919. As late as 1921, when the Federal-aid highway system was designated, there were less than 10,500,000 registered motor vehicles in the whole country. It will be seen, therefore, that while the States and the Federal Government have been carrying on their cooperative program of improvement of the Federal-aid system the traffic served by the system has been increasing at a very rapid rate and is now in all probability at least two and a half times as dense as

it was when the work of improvement began.

Naturally, so great an increase in traffic has greatly modified the requirements of road design in all parts of the country. With respect to the Federal-aid system the traffic conditions now existing in such States as Colorado, Utah, Arizona, and New Mexico require a type of improvement equivalent to that required in many of the Eastern States in 1921, and traffic in the more populous industrial States of the East has increased from that represented by an average motor vehicle registration of 152 per mile of the system to the density corresponding to a registration of 382 per mile.

Moreover, these increases in the density of travel on the country's most important roads have been accompanied by corresponding increases in the traffic on the local roads of all sections, so that thousands of miles of these roads now require for the proper accommodation of their traffic a degree of improvement which in 1921 was required only on the main roads.

With respect to the Federal-aid system, these increased traffic demands are being met, as previously stated by stage construction carried on concurrently with the extension of new improvement; but the improvement of the system as a whole is yet far from the standard that will ultimately be required in all sections, and lags behind the present need in most. These roads still remain the most important roads of the country; and although the utilization of all roads has increased, this limited system still serves the preponderance of the traffic. Its further improvement to the higher standard required, therefore, still remains the most important task, and the only task which is of concern to the Federal Government.

The problem of meeting the increased demands of traffic on the local roads is a matter of concern to the local and State governments, and there is evidence in the laws recently enacted by State legislatures that this matter is being given attention by the State governments. Such evidence is found in the application of a portion of the gasoline-tax revenue to local road purposes and in the laws recently enacted and proposed to give supervisory control over such roads to the State highway departments.

On all roads, and especially the important routes included in the Federal-aid system, solution of the problems raised by the increased traffic is not provided merely by the building of higher types of surfaces. A general widening of the surfaces is also required, and, in view of the greater speeds now customary and legally permissible, the easing and superelevation of curves, the cutting away of banks which obscure vision, and other improvements in detail which contribute to safety. The elimination of dangerous railroad grade crossings is an expensive but urgently required improvement, and on the more densely traveled roads it is already desirable to separate the grades of intersecting highways.

For the accomodation of heavy traffic the general types of pavement that have been developed have proved satisfactory. There is constant need, however, for improvement in the details of design and construction, not only to increase their strength and durability, but also to reduce costs and insure uniform excellence of construction. One of the notable recent improvements in the design of concrete pavements is the use of a raised edge which both strengthens the edge of the pavement and serves to prevent the dangerous and costly wearing down of shoulders.

In the construction of concrete pavements it is found also that much more uniform results are obtained by proportioning the fine and coarse aggregates by weight and by taking special precautions to maintain a uniform size grading of the coarse aggregate. This improvement has not yet been adopted by all State highway departments, but the bureau is taking every opportunity to impress its desirability upon those that have not yet adopted it, and will probably insist upon it in the projects undertaken hereafter.

For the roads that serve a somewhat lighter traffic the method of constructing a dustless, and relatively wear-resisting surface by mixture of bituminous material with fine crushed stone in place on the road continues to give very satisfactory results.

BRIDGE CONSTRUCTION

The bridges completed during the year, with their approaches, have an aggregate length of 43.6 miles. The bridges under construction and approved for construction at the end of the year have, with their approaches, a total length of 60.1 miles.

Including the structures just completed, the Federal-aid bridges now

standing have a total length, with their approaches of 266.9 miles.

A list of the bridges completed during the year which cost $75,000 or more is given in Table 13. These, the longest and most expensive of the projects completed, vary in length from about a tenth of a mile to upwards of 2 miles, and have an aggregate length, with their approaches, of 16.3 miles. The rest of the mileage completed is made up of numerous smaller and less expensive bridges, all more than 20 feet in span.

TABLE 13.—*Federal-aid bridges completed during the fiscal year 1929 at a cost of $75,000 or more each*

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
				Miles
Arkansas	At Dardanelle	Arkansas River	$587,600	0.4
Do	At Batesville	White River	348,200	.6
Do	Between Batesville and Tina	Ramsey Bottoms	216,500	.9
Do	At Marked Tree	St. Francis River	128,600	.3
California	Between Califa and Fresno	San Joaquin River	207,600	.2
Do	Near Orick	Redwood Creek	91,000	.1
Do	Near French Camp on Haywards-French Camp Road.	San Joaquin River	227,400	.4
Colorado	Near Swink on Pueblo-La Junta Highway.	Underpass, Atchison, Topeka & Santa Fe Railroad.	85,900	.3
Connecticut	At Saybrook	Overhead bridge over New York, New Haven & Hartford Railroad.	108,600	.5
Do	Between Groton and Preston	Poquetanock Cove	189,300	.3
Do	Between Watertown and Thomaston.	Over Naugatuck River, trolley tracks and New York, New Haven & Hartford Railroad.	357,500	.7
Do	At Windsor Locks	Bridge over New York, New Haven & Hartford Railroad.	120,300	.7
Florida	Between Jacksonville and Kingsland, Ga.	St. Marys River	188,200	.1
Idaho	Between Idaho Falls and Irwin	Snake River	84,500	.1
Indiana	Between Petersburg and Washington.	East Fork of the White River	202,700	.2
Kentucky	Near Shelbiana	Levisa Fork of Big Sandy River and Chesapeake & Ohio Railroad.	100,800	.1
Louisiana	At Clayton	Tensas River	161,200	.1
Do	Between New Orleans and Slidell	The Rigolets	122,900	2.2
Michigan	At Adrian	Underpass, Detroit, Toledo & Ironton Railroad.	90,200	.2
Minnesota	Trunk No. 5, near Shakopee	Minnesota River	144,300	.1
Missouri	Between Chillicothe and Utica	Grand River	131,600	.3
New Mexico	Near Albuquerque on Albuquerque-Isleta Road.	Rio Grande River	137,700	.5
Do	At Las Cruces	Viaduct over Atchison, Topeka & Santa Fe Railroad.	99,100	.2
New York	Between Moscow and Geneseo	Genesee River	102,900	.1
North Carolina	At Washington	Pamlico River	210,500	.2
North Dakota	At Chaloner's Ferry	Little Missouri River	101,200	.1
Ohio	At Ashtabula	Ashtabula River	388,900	.3
Oklahoma	Between Snyder and Altus	North Fork of Red River	238,100	.4
Do	Between Shawnee and Seminole County line.	North Canadian River	93,300	----------
Oregon	At Springfield	Willamette River	158,700	.5
Pennsylvania	On Tionesta-Irvine Road	Allegheny River	165,700	.1
South Carolina	Between Newberry and Winnsboro.	Broad River	182,900	.3
Do	Between Georgetown and McClellanville.	Santee River	361,300	2.2
Do	Between Whitmire and Chester	Broad River	126,200	.3
Do	Between Columbia and New Brookland.	Congaree River	531,200	.3
Tennessee	Between Memphis and Brownsville.	Wolf River	156,900	.6
Do	Between Dyersburg and Ripley	South Forked Deer River	140,400	.5
Texas	Near Houston on State Highway route No. 3.	San Jacinto River	110,100	.2
Do	Between Vernon and Quanah	Pease River	114,500	.3
Virginia	At Courtland	Nottoway River	89,200	.2
West Virginia	At Cotton Hill Station	Over Chesapeake & Ohio Railroad and New River.	160,000	.2

EFFECT OF RECENT FEDERAL LEGISLATION

The amendment of the Federal highway act approved May 21, 1928, provides that in the case of any State containing unappropriated public lands and nontaxable Indian lands exceeding 5 per cent of the total land area of the State in which the population does not exceed 10 per square mile, the Secretary of Agriculture may increase the share payable by the United States up to and including the whole cost of projects on the Federal-aid primary system and of projects on the secondary system when the latter is a continuation of a route of the primary system or directly connects with a route of the primary system of an adjoining State, It is further provided that where the Federal expenditure upon such projects exceeds the ordinary maximum pro rata, the State must expend upon some other project or projects on the Federal-aid system, within the same year and under the direction of the Secretary of Agriculture, the amount it would otherwise have been required to expend upon the project or projects to which additional aid is granted under the provisions of the amendment.

This amendment has been in effect throughout the fiscal year 1929. No State highway department has yet requested an increase in the share of the Federal Government payable on any project.

Section 3 of the amendment approved May 21, 1928, provides that the system of Federal-aid highways on which Federal funds may be expended in any State may exceed 7 per cent of the total highway mileage of the State by the amount of the mileage on the system within national forest, Indian, or other Federal reservations in the State.

Following the passage of this amendment the several State highway departments were called upon to submit a statement of the mileage on the system within Federal reservations. These statements have been received from all but two States—Tennessee and Georgia—affected by the amendment, and all that have been received have been approved by the Secretary of Agriculture with the exception of six which are noted in Table 14. The mileages reported for the other 24 States and Hawaii listed in the latter table are those agreed upon and represent the amount by which the 7 per cent mileage may be exceeded in accordance with the amendment.

TABLE 14.—*Mileage on Federal-aid highway system within Federal reservations, being the amounts by which the 7 per cent mileage may be exceeded in each State or Territory*

State	Mileage of Federal-aid system within Federal reservations	State	Mileage of Federal-aid system within Federal reservations	State	Mileage of Federal-aid system within Federal reservations	State	Mileage of Federal-aid system within Federal reservations
Ariz.	219.70	Ky.	6.00	N. Mex.	348.58	Utah	68.90
Ark.	119.70	Me.[1]	4.50	N. Y.[1]	16.47	Va.	30.72
Calif.	457.00	Mich.	26.50	N. C.	159.34	Wash.	349.69
Colo.	363.50	Minn.	74.80	N. Dak.	23.39	W. Va.	29.06
Idaho	368.90	Mont.	800.82	Okla.	16.25	Wis.	45.50
Iowa[1]	2.00	Nebr.[1]	11.25	Oreg.	360.10	Wyo.	271.90
Ill.	4.50	Nev.	26.25	Pa.	79.46	T. H.	4.35
Kans.	14.70	N. H.[1]	33.42	S. Dak.	450.50		

[1] Approval of reported mileage by Secretary of Agriculture pending. All other mileages reported have been approved.

The Federal highway act provided that before any project submitted in accordance therewith should be approved by the Secretary of Agriculture for any State, the State should make provision for State funds under the direct control of the State highway department in the amount required each year of the State for construction, reconstruction, and maintenance of Federal-aid highways within the State. At the time the act was passed there were certain States, the existing constitution or laws of which would not permit the State to provide revenues for highway purposes as required; and in recognition of this condition the Federal law authorized the Secretary of Agriculture to continue to approve projects for such States until three years after the passage of the act, which was approved November 9, 1921.

By subsequent amendments the full effectiveness of the requirement of the original act was three times deferred, the last amendment permitting approval of projects submitted under the appropriations authorized for the fiscal year 1929. The act of May 26, 1928, authorizing appropriations for the fiscal years 1930 and 1931 did not further extend the authority of the Secretary to waive the requirement of the original act. Consequently, all States will be expected to comply with the requirement on all projects involving the use of funds authorized to be appropriated for the fiscal year 1930 and subsequent fiscal years.

TREE PLANTING ON FEDERAL-AID HIGHWAYS

The passage of the first year since the amendment of the law authorizing Federal participation in the cost of planting shade trees along routes of the Federal-aid system has brought no proposal to that end from any State highway department. A number of States had already developed plans and begun such work along effective lines prior to the adoption of the Federal law, and their experiences indicates that the results are well worth the moderate expenditure entailed.

Through its monthly publication, Public Roads, which is circulated widely among State highway officials the bureau has published reports of the methods employed and results obtained in the splendid work of this character as carried on by the Massachusetts Department of Public Works, and informative articles with regard to the practice of other State departments will be published from time to time.

Inquiries received during the year from State highway departments, civic associations, and individuals indicate that there is considerable interest in the possible utilization of Federal aid for such plantings as a means of improving the appearance of the roadsides and enhancing the pleasure and comfort of travelers. Doubtless, there is at present in many States more pressing need to devote all available funds to other more utilitarian purposes; and States that now find it feasible to develop and carry out a systematic program of roadside beautification may prefer in some instances to use other than Federal funds for the purpose.

The department should not encourage expenditure for this purpose when to do so would mean the deferment of other more necessary improvements, and need not urge the employment of Federal aid if the States prefer to depend upon their own revenues; but the planting of suitable trees and shrubbery along all sections of the Federal-aid system where such growth can be maintained should be regarded as a necessary eventual step in the improvement of the system.

In this one respect the roads of the United States are as yet inferior to the highways of Europe. We have had too little regard for their appearance. Their greatest use is by those seeking pleasure and recreation by travel. To many such users a pleasant roadside prospect means as much as a smooth surface and easy grades. The satisfaction of this instinctive desire for beauty is an object that should no longer be ignored in our public works, and especially in the improvement of our highways. The department should lend its encouragement and offer its aid in every possible way toward this desirable end.

FEDERAL FUNDS APPORTIONED AND OBLIGATED

For the fiscal year 1929 the Federal-aid appropriation authorized was again $75,000,000. This sum, less 2½ per cent deducted for Federal administration and highway research, was apportioned among the several States and the Territory of Hawaii on December 1, 1927. The total amount apportioned was $73,125,000, and the amounts credited to each State are shown in Table 28.

As pointed out in the last annual report, the appropriations authorized for several years past in the amount of $75,000,000 have been exceeded each year by the obligations undertaken. This was possible in the beginning by reason of a large unobligated balance carried over from the earlier years, when obligations lagged behind the rate of appropriation. By June 30, 1927, these funds unobligated during the fiscal year for which they were authorized had been finally absorbed, and the fiscal year 1928 opened with an unobligated balance nearly $3.000,000 less than the apportionment for the year.

This balance was rapidly absorbed by new projects, and when the authorization for the fiscal year 1929 was apportioned the State highway departments, taking advantage of the pro-

vision of the law which permits the allotment of the apportioned funds prior to the beginning of the fiscal year for which they are apportioned, submitted projects to be paid for with the newly apportioned funds as soon as they became available. As a consequence, the unobligated balance of all apportioned funds, including the apportionment for the fiscal year 1929, was only $53,643,770.45. In other words, there had already been obligated, before the beginning of the fiscal year 1929, nearly $20,000,000 of the $73,125,000 authorized for the year.

The purpose of the provision of the law which permits the allotment of authorized funds approximately six months before the date when they become expendable was to enable the State highway departments to complete all necessary preliminary work such as the preparation of detailed plans, advertising for bids, and the execution of contracts, and be ready to begin actual construction on the new year's program promptly at the beginning of the year. No payment of the funds obligated may be made before the beginning of the fiscal year, however; and it is not intended that the provision of the law shall be used to carry on a construction program of greater magnitude than the annual authorizations will provide for. The purpose is to provide for the maintenance of a continuous program uninterrupted at the beginning of each fiscal year by the necessity of letting contracts, etc., after the money is actually available.

When a sufficient amount of work has been arranged for prior to the beginning of the fiscal year to permit of continuous operation nothing is to be gained by further anticipation of the newly available authorization.

This point has now been reached and, as shown by Table 15, the funds obligated during the fiscal year, for the first time since 1923, are within the sum apportioned. The year's expenditure, $82,097,380.38, as shown by Table 28, is still in excess of the rate of authorization, and it may be expected that this condition will exist for a year or two longer since there is a normal interval of from one to two years between obligation and expenditure of the money. But the point has now definitely been reached at which, unless there is immediate increase in the appropriations authorized, the rate of construction of Federal-aid roads, maintained for several years past, will be curtailed.

COST OF THE ROADS

The total cost of the 7,402.3 miles of initial construction and the 1,987.7 miles of stage construction completed during the year was $195,298,168.25, of which the Federal Government paid $82,736,878.92, or 42 per cent, and the States the balance. These expenditures were made over the period required to construct the roads brought to completion during the year, which was approximately two years. During the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal funds during the year was $82,097,380.38, as shown in Table 28. This was slightly over a million dollars more than the expenditures of the previous year.

TABLE 15.—*Federal-aid funds apportioned to the States and obligated by them for the fiscal years 1923 to 1929, inclusive*

Fiscal year	Apportioned amount of appropriation authorized for the year	Amount of Federal-aid funds obligated during the year
1923	$48,750,000	$77,461,559
1924	63,375,000	89,866,864
1925	73,125,000	87,294,396
1926	73,125,000	79,608,897
1927	73,125,000	77,453,046
1928	73,125,000	88,922,185
1929	73,125,000	70,428,896
Total	477,750,000	571,035,843
Average	68,250,000	81,576,549

The largest disbursements during the year were made to California, Illinois, Michigan, New York, Ohio, Pennsylvania, and Texas. To each of these States the Federal Government paid during the year more than $3,000,000. All other States received less than that amount.

SUMMARY OF FEDERAL-AID ROAD WORK, BY STATES

The progress made in each of the States during the year and the results of the 13 years of Federal-aid road construction are set forth in the fol-

lowing condensed summary for each State.

ALABAMA

The Federal-aid highway system includes 3,884 miles. After deduction of 5.5 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,960.7, of which 183.5 miles were added during the year. At the close of the year 245.7 miles were under construction and 6.4 miles were approved for construction.

The mileage improved with Federal aid consists of 143 miles of graded and drained earth roads, 534.1 miles of sand-clay, 912.5 miles of gravel, 11.6 miles of water-bound macadam, 74.1 miles of bituminous macadam, 87.6 miles of bituminous concrete and 189.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 7.9 miles.

The total cost of all Federal-aid roads completed during the year, including 68.2 miles of stage construction, was $4,293,128.01, of which the Federal share was $2,072,634.60. The disbursement of Federal funds to the State was $1,627,208.67. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,243,381.25.

ARIZONA

The Federal-aid highway system includes 1,498 miles. A total of 887.9 miles has been improved with Federal aid, of which 66.1 miles were added during the year. At the close of the year 130.6 miles were under construction.

The mileage improved with Federal aid consists of 181 miles of graded and drained earth roads, 101.1 miles of sand-clay, 426.4 miles of gravel, 14.2 miles of water-bound macadam, 13.6 miles of bituminous macadam, 38.1 miles of bituminous concrete, and 109.4 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 24 miles of stage construction, was $1,364,000.35, of which the Federal share was $892,597.99. The disbursement of Federal funds to the State was $1,309,267.51. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,653,890.02.

ARKANSAS

The Federal-aid highway system includes 5,019.4 miles. After deduction of 35.2 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,745.1, of which 108.7 miles were added during the year. At the close of the year 109.4 miles were under construction and 25.3 miles were approved for construction.

The mileage improved with Federal aid consists of 64.5 miles of graded and drained earth roads, 3 miles of sand-clay, 1,118.5 miles of gravel, 48.3 miles of water-bound macadam, 109.1 miles of bituminous macadam, 256.3 miles of bituminous concrete, and 139 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 6.4 miles.

The total cost of all Federal-aid roads completed during the year was $2,741,801.31, of which the Federal share was $1,325,478.27. The disbursement of Federal funds to the State was $1,377,002.44. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,104,522.21.

CALIFORNIA

The Federal-aid highway system includes 4,781 miles. A total of 1,625.6 miles has been improved with Federal aid, of which 171.7 miles were added during the year. At the close of the year 275.3 miles were under construction and 31.6 miles were approved for construction.

The mileage improved with Federal aid consists of 337.7 miles of graded and drained earth roads, 398.4 miles of gravel, 24.1 miles of water-bound macadam, 95.6 miles of bituminous macadam, 165.1 miles of bituminous concrete, and 596.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 7.8 miles.

The total cost of all Federal-aid roads completed during the year, including 9.3 miles of stage construction, was $6,650,687.38, of which the Federal share was $3,228,015.10. The dis-

bursement of Federal funds to the State was $3,433,055.14. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $821,207.18.

COLORADO

The Federal-aid highway system includes 3,332 miles. A total of 1,137.4 miles has been improved with Federal aid, of which 175.1 miles were added during the year. At the close of the year 155.4 miles were under construction and 25.8 miles were approved for construction.

The mileage improved with Federal aid consists of 232.4 miles of graded and drained earth roads, 96.2 miles of sand-clay, 480.8 miles of gravel, 5.3 miles of water-bound macadam, 13 miles of bituminous concrete, and 298.8 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 10.9 miles.

The total cost of all Federal-aid roads completed during the year, including 14.8 miles of stage construction, was $5,105,451.40, of which the Federal share was $2,593,610.46. The disbursement of Federal funds to the State was $1,803,610.66. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,673,794.83.

CONNECTICUT

The Federal-aid highway system includes 835.4 miles. A total of 229.3 miles has been improved with Federal aid, of which 22.8 miles were added during the year. At the close of the year 12.5 miles were under construction and 8 miles were approved for construction.

The mileage improved with Federal aid consists of 0.2 mile of gravel, 17.4 miles of water-bound macadam, 28.7 miles of bituminous macadam, 0.6 mile of bituminous concrete, and 178.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.9 miles.

The total cost of all Federal-aid roads completed during the year, including 0.1 mile of stage construction, was $2,181,298.64, of which the Federal share was $606,132.05. The disbursement of Federal funds to the State was $1,059,461.12. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $558,722.80.

DELAWARE

The Federal-aid highway system includes 485.9 miles. A total of 212.9 miles has been improved with Federal aid, of which 13.4 miles were added during the year. At the close of the year 15.7 miles were under construction and 30.8 miles were approved for construction.

The mileage improved with Federal aid consists of 4.9 miles of water-bound macadam, 7 miles of bituminous macadam, 13.7 miles of bituminous concrete, 180.6 miles of Portland cement concrete, and 6.2 miles of brick, in addition to which there are bridges and their approaches with a total length of 0.5 mile.

The total cost of all Federal-aid roads completed during the year, including 3.9 miles of stage construction, was $678,062.40, of which the Federal share was $198,900.72. The disbursement of Federal funds to the State was $142,185.23. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $47,336.16.

FLORIDA

The Federal-aid highway system includes 1,926 miles. A total of 449 miles has been improved with Federal aid, of which 63.6 miles were added during the year. At the close of the year 96.6 miles were under construction.

The mileage improved with Federal aid consists of 9.2 miles of graded and drained earth roads, 15.5 miles of sand-clay, 131.1 miles of water-bound macadam, 78.9 miles of bituminous macadam, 53.6 miles of bituminous concrete, 143.2 miles of Portland cement concrete, and 10.1 miles of brick, in addition to which there are bridges and their approaches with a total length of 7.4 miles.

The total cost of all Federal-aid roads completed during the year was $2,643,407.24, of which the Federal share was $1,125,163.19. The disbursement of Federal funds to the State was $894,258.16. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,965,926.62.

GEORGIA

The Federal-aid highway system includes 5,576.7 miles. A total of 2,564.6 miles has been improved with

Federal aid, of which 113.6 miles were added during the year. At the close of the year 200.8 miles were under construction and 2.9 miles were approved for construction.

The mileage improved with Federal aid consists of 217.4 miles of graded and drained earth roads, 1,178.1 miles of sand-clay, 390.7 miles of gravel, 144.2 miles of water-bound macadam, 151.8 miles of bituminous macadam, 43.1 miles of bituminous concrete, 411.5 miles of Portland cement concrete, and 0.5 mile of brick, in addition to which there are bridges and their approaches with a total length of 27.3 miles.

The total cost of all Federal-aid roads completed during the year, including 45.2 miles of stage construction, was $2,956,121.78, of which the Federal share was $1,332,729.37. The disbursement of Federal funds to the State was $1,446,496.98. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,018,492.49.

IDAHO

The Federal-aid highway system includes 2,770 miles. A total of 1,144.5 miles has been improved with Federal aid, of which 150.8 miles were added during the year. At the close of the year 77.5 miles were under construction and 16.3 miles were approved for construction.

The mileage improved with Federal aid consists of 201.6 miles of graded and drained earth roads, 6 miles of sand-clay, 760.7 miles of gravel, 22.5 miles of water-bound macadam, 20.7 miles of bituminous macadam, 85 miles of bituminous concrete, and 44.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.4 miles.

The total cost of all Federal-aid roads completed during the year, including 66.5 miles of stage construction, was $2,435,074.59, of which the Federal share was $1,441,742.26. The disbursement of Federal funds to the State was $1,270,906.07. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $856,815.71.

ILLINOIS

The Federal-aid highway system includes 6,618.5 miles. A total of 1,888.6 miles has been improved with Federal aid, of which 203.2 miles were added during the year. At the close of the year 572.8 miles were under construction and 22.5 miles were approved for construction.

The mileage improved with Federal aid consists of 153.7 miles of graded and drained earth roads, 0.4 mile of gravel, 3.3 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1.695 miles of Portland cement concrete, and 25.8 miles of brick, in addition to which there are bridges and their approaches with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year was $6,121,046.35, of which the Federal share was $2,794,215.01. The disbursement of Federal funds to the State was $5,682,636.43. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,642,000.

INDIANA

The Federal-aid highway system includes 4,701.5 miles. A total of 1,266.7 miles has been improved with Federal aid, of which 203.1 miles were added during the year. At the close of the year 275.9 miles were under construction and 35.3 miles were approved for construction.

The mileage improved with Federal aid consists of 16.5 miles of graded and drained earth roads, 42.2 miles of gravel, 41.6 miles of water-bound macadam, 23.4 miles of bituminous macadam, 12 miles of bituminous concrete, 1,120.3 miles of Portland cement concrete, and 6.6 miles of brick, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 3.5 miles of stage construction, was $6,412,238.71, of which the Federal share was $2,988,535.95. The disbursement of Federal funds to the State was $2,374,265.04. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $134,519.81.

IOWA

The Federal-aid highway system includes 7,212 miles. A total of 3,009.1 miles has been improved with Federal aid, of which 123.1 miles were added during the year. At the close of the year 135.7 miles were under construction and 25.7 miles were approved for construction.

The mileage improved with Federal aid consists of 1,329 miles of graded and drained earth roads, 616.6 miles of gravel, 1,039.6 miles of Portland cement concrete, and 21.9 miles of brick, in addition to which there are bridges and their approaches with a total length of 2 miles.

The total cost of all Federal-aid roads completed during the year, including 170.5 miles of stage construction, was $7,457,609.97, of which the Federal share was $3,382,766.29. The disbursement of Federal funds to the State was $2,704,154.16. All apportionments to the State up to June 30, 1929, had been fully obligated.

KANSAS

The Federal-aid highway system includes 7,917 miles. After deduction of 1.5 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 2,539.4, of which 338.6 miles were added during the year. At the close of the year 243.8 miles were under construction and 135.9 miles were approved for construction.

The mileage improved with Federal aid consists of 1,033.6 miles of graded and drained earth roads, 280.5 miles of sand-clay, 236.2 miles of gravel, 4.5 miles of water-bound macadam, 125.5 miles of bituminous macadam, 3.4 miles of bituminous concrete, 678.8 miles of Portland cement concrete, and 163.3 miles of brick, in addition to which there are bridges and their approaches with a total length of 13.6 miles.

The total cost of all Federal-aid roads completed during the year, including 22.9 miles of stage construction, was $5,335,022.24, of which the Federal share was $2,378,160.82. The disbursement of Federal funds to the State was $2,005,221.08. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,144,315.96.

KENTUCKY

The Federal-aid highway system includes 3,710 miles. A total of 1,314.5 miles has been improved with Federal aid, of which 169.0 miles were added during the year. At the close of the year 247.2 miles were under construction and 40.3 miles were approved for construction.

The mileage improved with Federal aid consists of 625.3 miles of graded and drained earth roads, 253.8 miles of gravel, 41.3 miles of water-bound macadam, 201.9 miles of bituminous macadam, 14.6 miles of bituminous concrete, 170.4 miles of Portland cement concrete, and 3.9 miles of brick, in addition to which there are bridges and their approaches with a total length of 3.3 miles.

The total cost of all Federal-aid roads completed during the year was $3,749,994.06, of which the Federal share was $1,830,900.22. The disbursement of Federal funds to the State was $1,504,667.75. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $757,788.11.

LOUISIANA

The Federal-aid highway system includes 2,712.9 miles. After deduction of 1.1 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,321.4, of which 46.5 miles were added during the year. At the close of the year 151.9 miles were under construction and 0.2 mile was approved for construction.

The mileage improved with Federal aid consists of 30.6 miles of graded and drained earth roads, 1,194 miles of gravel, 3.2 miles of water-bound macadam, 9.5 miles of bituminous macadam, 33.5 miles of bituminous concrete and 39.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 10.7 miles.

The total cost of all Federal-aid roads completed during the year was $1,240,120.23, of which the Federal share was $611,432.56. The disbursement of Federal funds to the State was $886,011.42. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,150,105.07.

MAINE

The Federal-aid highway system includes 1,443.6 miles. A total of 480.5 miles has been improved with Federal aid, of which 51.8 miles were added during the year. At the close of the year 44.3 miles were under construction and 29.7 miles were approved for construction.

The mileage improved with Federal aid consists of 214.8 miles of gravel, 8.6 miles of water-bound macadam, 167.6 miles of bituminous macadam, and 88.9 miles of Portland cement concrete, in addition to which there are

bridges and their approaches with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed during the year was $1,583,052.78, of which the Federal share was $649,921.57. The disbursement of Federal funds to the State was $229,792.30. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,111,122.42.

MARYLAND

The Federal-aid highway system includes 1,557.1 miles. A total of 627.9 miles has been improved with Federal aid, of which 70.5 miles were added during the year. At the close of the year 3.6 miles were under construction and 39.3 miles were approved for construction.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of gravel, 1.2 miles of water-bound macadam, 235.7 miles of bituminous macadam, 22.1 miles of bituminous concrete, and 332.7 miles of Portland cement concrete.

The total cost of all Federal-aid roads completed during the year, including 10.8 miles of stage construction, was $1,847,190.79 of which the Federal share was $815,265.86. The disbursement of Federal funds to the State was $712,060.20. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $213,725.37.

MASSACHUSETTS

The Federal-aid highway system includes 1,308 miles. After deduction of 0.1 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 570.7, of which 69.7 miles were added during the year. At the close of the year 91.1 miles were under construction and 1.9 miles were approved for construction.

The mileage improved with Federal aid consists of 0.5 mile of gravel, 6.6 miles of water-bound macadam, 308.6 miles of bituminous macadam, 59.5 miles of bituminous concrete and 191.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4 miles.

The total cost of all Federal-aid roads completed during the year, including 0.2 mile of stage construction, was $3,087,998.38, of which the Federal share was $1,064,911.57. The disbursement of Federal funds to the State was $825,636.10. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,787,319.03.

MICHIGAN

The Federal-aid highway system includes 5,243 miles. After deduction of 20.9 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,470.2, of which 153.8 miles were added during the year. At the close of the year 251.3 miles were under construction and 51.6 miles were approved for construction.

The mileage improved with Federal aid consists of 10.5 miles of graded and drained earth roads, 358.3 miles of gravel, 16.3 miles of water-bound macadam, 10.4 miles of bituminous macadam, 69.5 miles of bituminous concrete, 1,002.8 miles of Portland cement concrete, and 0.4 mile of brick, in addition to which there are bridges and their approaches with a total length of 2 miles.

The total cost of all Federal-aid roads completed during the year, including 0.3 mile of stage construction, was $5,940,513.07, of which the Federal share was $2,405,266.86. The disbursement of Federal funds to the State was $3,090,670.12. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,424,179.67.

MINNESOTA

The Federal-aid highway system includes 6,884.5 miles. After deduction of 178.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 3,872.6, of which 257 miles were added during the year. At the close of the year 291 miles were under construction and 74.7 miles were approved for construction.

The mileage improved with Federal aid consists of 852.2 miles of graded and drained earth roads, 6.2 miles of sand-clay, 2,261.5 miles of gravel, 32.7 miles of bituminous concrete and 718.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed during the year, including 117.9 miles of stage construc-

tion, was $8,303,728.19, of which the Federal share was $2,879,041.58. The disbursement of Federal funds to the State was $2,216,048.53. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $410,000.

MISSISSIPPI

The Federal-aid highway system includes 3,632.1 miles. A total of 1,656.5 miles has been improved with Federal aid, of which 109.5 miles were added during the year. At the close of the year 213.8 miles were under construction and 12.9 miles were approved for construction.

The mileage improved with Federal aid consists of 233.5 miles of graded and drained earth roads, 16.7 miles of sand-clay, 1,158.3 miles of gravel, 11.1 miles of water-bound macadam, 1.5 miles of bituminous macadam, 10.4 miles of bituminous concrete, 208 miles of Portland cement concrete, and 9.7 miles of brick, in addition to which there are bridges and their approaches, with a total length of 7.3 miles.

The total cost of all Federal-aid roads completed during the year, including 30.9 miles of stage construction, was $1,750,251.06, of which the Federal share was $866,977.76. The disbursement of Federal funds to the State was $1,306,196.99. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,361,970.25.

MISSOURI

The Federal-aid highway system includes 7,530 miles. A total of 2,278.1 miles has been improved with Federal aid, of which 99.6 miles were added during the year. At the close of the year 268 miles were under construction and 16.5 miles were approved for construction.

The mileage improved with Federal aid consists of 387.5 miles of graded and drained earth roads, 2.6 miles of sand-clay, 796.6 miles of gravel, 3 miles of water-bound macadam, 44.8 miles of bituminous macadam, 17.7 miles of bituminous concrete, 994.9 miles of Portland-cement concrete, and 20.9 miles of brick, in addition to which there are bridges and their approaches, with a total length of 10.1 miles.

The total cost of all Federal-aid roads completed during the year, including 64.2 miles of stage construction, was $3,922,393.41, of which the Federal share was $1,545,883.79. The disbursement of Federal funds to the State was $2,422,487.79. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $136,556.02.

MONTANA

The Federal-aid highway system includes 4,690.5 miles. After deduction of 0.2 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,538.9, of which 244.2 miles were added during the year. At the close of the year 362.3 miles were under construction and 166 miles were approved for construction.

The mileage improved with Federal aid consists of 224.1 miles of graded and drained earth roads, 5.6 miles of sand-clay, 1,240.1 miles of gravel, 15.9 miles of water-bound macadam, 6.8 miles of bituminous macadam, 5.6 miles of bituminous concrete, and 36 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.8 miles.

The total cost of all Federal-aid roads completed during the year, including 13.4 miles of stage construction, was $2,836,700.85, of which the Federal share was $1,834,170.77. The disbursement of Federal funds to the State was $1,923,168.90. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $3,613,761.84.

NEBRASKA

The Federal-aid highway system includes 5,468.3 miles. After deduction of 0.2 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 3,628.1, of which 460.2 miles were added during the year. At the close of the year 300.7 miles were under construction and 54 miles were approved for construction.

The mileage improved with Federal aid consists of 566.1 miles of graded and drained earth roads, 2,129.1 miles of sand-clay, 812.3 miles of gravel, 1.5 miles of bituminous macadam, 14.2 miles of bituminous concrete, 77 miles of Portland cement concrete, and 19.6 miles of brick, in addition to which there are bridges and their approaches with a total length of 8.2 miles.

The total cost of all Federal-aid roads completed during the year, in-

cluding 182.5 miles of stage construction, was $4,434,167.82, of which the Federal share was $2.140,403.77. The disbursement of Federal funds to the State was $1,225,896.80. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,539,681.66.

NEVADA

The Federal-aid highway system includes 1,541 miles. After deduction of less than 0.1 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,081.6, of which 147 miles were added during the year. At the close of the year 226.9 miles were under construction and 0.6 mile was approved for construction.

The mileage improved with Federal aid consists of 51.2 miles of graded and drained earth roads, 9.7 miles of sand-clay, S33.4 miles of gravel, 14.9 miles of water-bound macadam, 122.5 miles of bituminous macadam, 2 miles of bituminous concrete, and 45.2 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 2.7 miles.

The total cost of all Federal-aid roads completed during the year, including 60.8 miles of stage construction, was $1,313,310.42, of which the Federal share was $1,120,157.11. The disbursement of Federal funds to the State was $863,467.12. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $204,689.18.

NEW HAMPSHIRE

The Federal-aid highway system includes 980.9 miles. A total of 332.7 miles has been improved with Federal aid, of which 28.1 miles were added during the year. At the close of the year 13.5 miles were under construction and 6.5 miles were approved for construction.

The mileage improved with Federal aid consists of 99.2 miles of gravel, 70 miles of water-bound macadam, 92.4 miles of bituminous macadam, 32.4 miles of bituminous concrete, and 34.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year was $1,001,020.85, of which the Federal share was $409,954.34. The disbursement of Federal funds to the State was $365,278.82. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $188,-125.54.

NEW JERSEY

The Federal-aid highway system includes 1,181.7 miles. A total of 462.6 miles has been improved with Federal aid, of which 44.4 miles were added during the year. At the close of the year 54.3 miles were under construction and 8.7 miles were approved for construction.

The mileage improved with Federal aid consists of 8.9 miles of graded and drained earth roads, 5.6 miles of gravel, 22.3 miles of bituminous concrete, and 423.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year was $2,847,737.45, of which the Federal share was $659,548.27. The disbursement of Federal funds to the State was $768,902.44. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $625,470.08.

NEW MEXICO

The Federal-aid highway system includes 3,367.7 miles. After deduction of 9.9 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,868.1, of which 137.6 miles were added during the year. At the close of the year 137.6 miles were under construction and 9 miles were approved for construction.

The mileage improved with Federal aid consists of 273.1 miles of graded and drained earth roads, 5.1 miles of sand-clay, 1,503.2 miles of gravel, 0.7 mile of bituminous concrete, and 81.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 5.6 miles of stage construction, was $2,229,501.77, of which the Federal share was $1,467,188.58. The disbursement of Federal funds to the State was $2,106,513.24. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,153,455.48.

NEW YORK

The Federal-aid highway system includes 5,451 miles. After deduction of 1.1 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 2,182.7, of which 318.9 miles were added during the year. At the close of the year 343.6 miles were under construction and 137.5 miles were approved for construction.

The mileage improved with Federal aid consists of 21.6 miles of graded and drained earth roads, 46 miles of sand-clay, 58.4 miles of gravel, and 361.7 miles of bituminous macadam, 12.6 miles of bituminous concrete, 1,721.2 miles of Portland cement concrete, and 0.7 mile of brick, in addition to which there are bridges and their approaches with a total length of 1.9 miles.

The total cost of all Federal-aid roads completed during the year, including 8.5 miles of stage construction, was $17,998,988.48, of which the Federal share was $5,030,321.47. The disbursement of Federal funds to the State was $3,761,689.93. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $4,295,740.58.

NORTH CAROLINA

The Federal-aid highway system includes 3,944.4 miles. A total of 1,711.9 miles has been improved with Federal aid, of which 125.6 miles were added during the year. At the close of the year 87.6 miles were under construction and 14.2 miles were approved for construction.

The mileage improved with Federal aid consists of 103.8 miles of graded and drained earth roads, 459.7 miles of sand-clay, 63.6 miles of gravel, 19.6 miles of water-bound macadam, 37.9 miles of bituminous macadam, 249.5 miles of bituminous concrete, and 774.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.2 miles.

The total cost of all Federal-aid roads completed during the year, including 25.6 miles of stage construction, was $3,347,608.32, of which the Federal share was $1,558,571.88. The disbursement of Federal funds to the State was $1,716,874.85. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,721,786.21.

NORTH DAKOTA

The Federal-aid highway system includes 7,396.6 miles. After deduction of 7.1 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 3,676.5, of which 500.6 miles were added during the year. At the close of the year 620.7 miles were under construction and 124.7 miles were approved for construction.

The mileage improved with Federal aid consists of 1,344.1 miles of graded and drained earth roads, 2,313.4 miles of gravel, 5.4 miles of water-bound macadam, 1.9 miles of bituminous concrete, and 4.7 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 7 miles.

The total cost of all Federal-aid roads completed during the year, including 331.3 miles of stage construction was $2,965,387.55, of which the Federal share was $1,358,653.48. The disbursement of Federal funds to the State was $1,325,962.17. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $982,621.03.

OHIO

The Federal-aid highway system includes 5,899.3 miles. A total of 2,013.1 miles has been improved with Federal aid, of which 201.2 miles were added during the year. At the close of the year 257.2 miles were under construction and 59.7 miles were approved for construction.

The mileage improved with Federal aid consists of 104 miles of graded and drained earth roads, 7.9 miles of gravel, 143.1 miles of water-bound macadam, 400.5 miles of bituminous macadam, 97.3 miles of bituminous concrete, 757 miles of Portland cement concrete, and 500.1 miles of brick, in addition to which there are bridges and their approaches with a total length of 3.2 miles.

The total cost of all Federal-aid roads completed during the year, including 12.1 miles of stage construction, was $7,216,174.12, of which the Federal share was $2,876,713.72. The disbursement of Federal funds to the State was $3,937,359.91. The unobligated balance available on June 30, 1929, of all appropriations authorized

and apportioned up to that date was $2,755,365.68.

OKLAHOMA

The Federal-aid highway system includes 5,594.3 miles. A total of 1,823.7 miles has been improved with Federal aid, of which 233.3 miles were added during the year. At the close of the year 84.6 miles were under construction and 38.4 miles were approved for construction.

The mileage improved with Federal aid consists of 416.1 miles of graded and drained earth roads, 2.3 miles of sand-clay, 605.6 miles of gravel, 6.3 miles of water-bound macadam, 49.5 miles of bituminous macadam, 102.2 miles of bituminous concrete, 620.5 miles of Portland cement concrete, and 8.9 miles of brick, in addition to which there are bridges and their approaches with a total length of 12.3 miles.

The total cost of all Federal-aid roads completed during the year, including 44 miles of stage construction, was $5,303,528.87 of which the Federal share was $2,391,756.26. The disbursement of Federal funds to the State was $1,614,336.80. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $913,425.83.

OREGON

The Federal-aid highway system includes 3,239.7 miles. A total of 1,147.9 miles has been improved with Federal aid, of which 43 miles were added during the year. At the close of the year 48.2 miles were under construction and 72.9 miles were approved for construction.

The mileage improved with Federal aid consists of 155 miles of graded and drained earth roads, 799.1 miles of gravel, 25.6 miles of water-bound macadam, 11.5 miles of bituminous macadam, 52.9 miles of bituminous concrete, and 99.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.9 miles.

The total cost of all Federal-aid roads completed during the year was $1,776,270.44, of which the Federal share was $922,764.06. The disbursement of Federal funds to the State was $544,205.11. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,430,698.62.

PENNSYLVANIA

The Federal-aid highway system includes 5,058.2 miles. A total of 2,072.9 miles has been improved with Federal aid, of which 250 miles were added during the year. At the close of the year 216.6 miles were under construction and 81.9 miles were approved for construction.

The mileage improved with Federal aid consists of 137.9 miles of graded and drained earth roads, 18.4 miles of bituminous macadam, 101.1 miles of bituminous concrete, 1,786.9 miles of Portland cement concrete, and 26.4 miles of brick, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year was $12,453,120.64, of which the Federal share was $3,958,562.36. The disbursement of Federal funds to the State was $3,801,073.14. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,855,478.52.

RHODE ISLAND

The Federal-aid highway system includes 362.4 miles. A total of 165.2 miles has been improved with Federal aid, of which 29 miles were added during the year. At the close of the year 23.9 miles were under construction and 1.5 miles were approved for construction.

The mileage improved with Federal aid consists of 1.8 miles of water-bound macadam, 44.2 miles of bituminous macadam, 49.7 miles of bituminous concrete, and 69.4 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 0.1 mile.

The total cost of all Federal-aid roads completed was $1,637,611.43, of which the Federal share was $479,326.40. The disbursement of Federal funds to the State was $402,771. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $548,347.68.

SOUTH CAROLINA

The Federal-aid highway system includes 3,230 miles. After deduction of less than 0.1 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,813.7, of which 98.8 miles were added during the

year. At the close of the year 166.3 miles were under construction and 14.2 miles were approved for construction.

The mileage improved with Federal aid consists of 25.3 miles of graded and drained earth roads, 1,236.4 miles of sand-clay, 123 miles of gravel, 8.9 miles of water-bound macadam, 10.7 miles of bituminous macadam, 154.4 miles of bituminous concrete, 237.4 miles of Portland cement concrete, and 0.2 mile of brick, in addition to which there are bridges and their approaches with a total length of 17.4 miles.

The total cost of all Federal-aid roads completed during the year, including 90.3 miles of stage construction, was $5,493,642.34, of which the Federal share was $1,289,919.53. The disbursement of Federal funds to the State was $816,484.11. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $886,629.83.

SOUTH DAKOTA

The Federal-aid highway system includes 6,001.5 miles. A total of 3,310.8 miles has been improved with Federal aid, of which 450.7 miles were added during the year. At the close of the year 536.3 miles were under construction and 49 miles were approved for construction.

The mileage improved with Federal aid consists of 264.5 miles of graded and drained earth roads, 35 miles of sand-clay, 2,996.9 miles of gravel, 4 miles of bituminous macadam, and 7.2 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.2 miles.

The total cost of all Federal-aid roads completed during the year, including 125.1 miles of stage construction, was $2,526,718.82, of which the Federal share was $1,345,451.61. The disbursement of Federal funds to the State was $1,107,488.48. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $371,595.94.

TENNESSEE

The Federal-aid highway system includes 3,252.8 miles. A total of 1,148.4 miles has been improved with Federal aid, of which 72.8 miles were added during the year. At the close of the year 119.8 miles were under construction and 15.9 miles were approved for construction.

The mileage improved with Federal aid consists of 67.2 miles of graded and drained earth roads, 123.8 miles of gravel, 52.3 miles of water-bound macadam, 428.7 miles of bituminous macadam, 40.5 miles of bituminous concrete and 431.3 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.6 miles.

The total cost of all Federal-aid roads completed during the year, including 118.6 miles of stage construction, was $5,010,358.01, of which the Federal share was $2,231,811.60. The disbursement of Federal funds to the State was $2,245,874.99. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,096,306.59.

TEXAS

The Federal-aid highway system includes 11,691 miles. After deduction of 7.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 6,064.1, of which 235.3 miles were added during the year. At the close of the year 911.1 miles were under construction and 173.2 miles were approved for construction.

The mileage improved with Federal aid consists of 567.2 miles of graded and drained earth roads, 90.4 miles of sand-clay, 2,937.9 miles of gravel, 518.8 miles of water-bound macadam, 886.3 miles of bituminous macadam, 137.2 miles of bituminous concrete, 883.8 miles of Portland cement concrete, and 29.2 miles of brick, in addition to which there are bridges and their approaches with a total length of 13 3 miles.

The total cost of all Federal-aid roads completed during the year, including 197.2 miles of stage construction, was $9,233,596.56, of which the Federal share was $4,016,467.80. The disbursement of Federal funds to the State was $4,191,191.70. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $36,517.80.

UTAH

The Federal-aid highway system includes 1,686.3 miles. A total of 918.3

miles has been improved with Federal aid, of which 99.8 miles were added during the year. At the close of the year 68 miles were under construction and 18.4 miles were approved for construction.

The mileage improved with Federal aid consists of 105.3 miles of graded and drained earth roads, 40.8 miles of sand-clay, 607 miles of gravel, 23.8 miles of water-bound macadam, 29.7 miles of bituminous macadam, 9.9 miles of bituminous concrete, and 99.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches, with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year, including 29.8 miles of stage construction, was $1,331,229.22, of which the Federal share was $963,406.50. The disbursement of Federal funds to the State was $1,066,011.51. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $361,621.97.

VERMONT

The Federal-aid highway system includes 1,043 miles. A total of 229 miles has been improved with Federal aid, of which 27.6 miles were added during the year. At the close of the year 38.1 miles were under construction and 0.1 mile was approved for construction.

The mileage improved with Federal aid consists of 101.9 miles of gravel, 8.2 miles of water-bound macadam, 51.6 miles of bituminous macadam, and 60.8 miles of Portland cement concrete, in addition to which there are bridges and their approaches, with a total length of 6.5 miles.

The total cost of all Federal-aid roads completed during the year was $1,174,278.93, of which the Federal share was $418,215.18. The disbursement of Federal funds to the State was $406,248.51. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $62,786.68.

VIRGINIA

The Federal-aid highway system includes 3,291.5 miles. After deduction of 8.9 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,345.5, of which 84.8 miles were added during the year. At the close of the year 114.2 miles were under construction and 22.1 miles were approved for construction.

The mileage improved with Federal aid consists of 55.1 miles of graded and drained earth roads, 203.4 miles of sand-clay, 116.2 miles of gravel, 107.2 miles of water-bound macadam, 357.9 miles of bituminous macadam, 13.7 miles of bituminous concrete, and 487.7 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.3 miles.

The total cost of all Federal-aid roads completed during the year, including 6.3 miles of stage construction, was $2,501,862.94, of which the Federal share was $1,108,813.98. The disbursement of Federal funds to the State was $1,297,653.57. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $758,318.82.

WASHINGTON

The Federal-aid highway system includes 2,927.5 miles. A total of 854.4 miles has been improved with Federal aid, of which 76.7 miles were added during the year. At the close of the year 91.2 miles were under construction and 21.9 miles were approved for construction.

The mileage improved with Federal aid consists of 171 miles of graded and drained earth roads, 371.6 miles of gravel, and 307.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.3 miles.

The total cost of all Federal-aid roads completed during the year, including 5 miles of stage construction, was $2,095,070.15, of which the Federal share was $872,594.07. The disbursement of Federal funds to the State was $1,498,282.57. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $917,100.03.

WEST VIRGINIA

The Federal-aid highway system includes 2,214 miles. A total of 683.3 miles has been improved with Federal aid, of which 94.1 miles were added during the year. At the close of the year 86.7 miles were under construc-

tion and 24.8 miles were approved for construction.

The mileage improved with Federal aid consists of 272.6 miles of graded and drained earth roads, 3.9 miles of sand-clay, 25.4 miles of gravel, 4.8 miles of water-bound macadam, 170.8 miles of bituminous macadam, 22.9 miles of bituminous concrete, 170 miles of Portland cement concrete, and 11.4 miles of brick, in addition to which there are bridges and their approaches with a total length of 1.5 miles.

The total cost of all Federal-aid roads completed during the year, was $2,287,197.12, of which the Federal share was $1,071,351.56. The disbursement of Federal funds to the State was $1,090,621.80. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $77,371.86.

WISCONSIN

The Federal-aid highway system includes 5,493.4 miles. After deduction of 197.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 2,056.1, of which 211 miles were added during the year. At the close of the year 336.4 miles were under construction and 38.9 miles were approved for construction.

The mileage improved with Federal aid consists of 146.3 miles of graded and drained earth roads, 84 miles of sand-clay, 1,011.1 miles of gravel, 6.7 miles of water-bound macadam, 13.8 miles of bituminous macadam, 0.5 mile of bituminous concrete, and 791.3 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed during the year, including 35.8 miles of stage construction, was $6,057,896.17, of which the Federal share was $2,804,171.88. The disbursement of Federal funds to the State was $2,438,786.46. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $338,759.36.

WYOMING

The Federal-aid highway system includes 3,097 miles. After deduction of 10.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,674.5, of which 219.6 miles were added during the year. At the close of the year 164 miles were under construction and 28.7 miles were approved for construction.

The mileage improved with Federal aid consists of 523.3 miles of graded and drained earth roads, 483.3 miles of sand-clay, 581.6 miles of gravel, 21.4 miles of water-bound macadam, 21.2 miles of bituminous macadam, 22.1 miles of bituminous concrete, and 15.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 5.7 miles.

The total cost of all Federal-aid roads completed during the year, including 42.6 miles of stage construction, was $2.063,080.42, of which the Federal share was $1,285,898.27. The disbursement of Federal funds to the State was $1,165,778.45. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $313,862.69.

HAWAII

The Federal-aid highway system includes 174.6 miles. A total of 39.5 miles has been improved with Federal aid, of which 3.3 miles were added during the year. At the close of the year 6.6 miles were under construction and 16.6 miles were approved for construction.

The mileage improved with Federal aid consists of 11.5 miles of bituminous macadam, 8.6 miles of bituminous concrete, and 19 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 0.4 mile.

The total cost of all Federal-aid roads completed during the year was $361,916.22, of which the Federal share was $90,400.62. The disbursement of Federal funds to the Territory was $92,158.11. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,072,664.16.

FEDERAL-AID STATISTICS

Statistical information relative to the apportionment, obligation, and disbursement of Federal aid during the fiscal year 1929; the cost of roads completed and the estimated cost of roads under construction; and the type of the roads completed and under construction, etc, is given in Tables 16 to 28, inclusive.

TABLE 16.—*Mileage of the designated Federal-aid highway system in each State and mileage improved with Federal aid to June 30, 1929*

State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1929	State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1929
Alabama	3,884.0	1,960.7	New Hampshire	980.9	332.7
Arizona	1,498.0	887.9	New Jersey	1,181.7	462.6
Arkansas	5,019.4	1,745.1	New Mexico	3,367.7	1,868.1
California	4,781.0	1,625.6	New York	5,451.0	2,182.7
Colorado	3,332.0	1,137.4	North Carolina	3,944.4	1,711.9
Connecticut	835.4	229.3	North Dakota	7,396.6	3,676.5
Delaware	485.9	212.9	Ohio	5,899.3	2,013.1
Florida	1,926.0	449.0	Oklahoma	5,594.3	1,823.7
Georgia	5,576.7	2,564.6	Oregon	3,239.7	1,147.9
Idaho	2,770.0	1,144.5	Pennsylvania	5,058.2	2,072.9
Illinois	6,618.5	1,888.6	Rhode Island	362.4	165.2
Indiana	4,701.5	1,266.7	South Carolina	3,230.0	1,813.7
Iowa	7,212.0	3,009.1	South Dakota	6,001.5	3,310.8
Kansas	7,917.0	2,539.4	Tennessee	3,252.8	1,148.4
Kentucky	3,710.0	1,314.5	Texas	11,691.0	6,064.1
Louisiana	2,712.9	1,321.4	Utah	1,686.3	918.3
Maine	1,443.6	480.5	Vermont	1,043.0	229.0
Maryland	1,557.1	627.9	Virginia	3,291.5	1,345.5
Massachusetts	1,308.0	570.7	Washington	2,927.5	854.4
Michigan	5,243.0	1,470.2	West Virginia	2,214.0	683.3
Minnesota	6,884.5	3,872.6	Wisconsin	5,493.4	2,056.1
Mississippi	3,632.1	1,656.5	Wyoming	3,097.0	1,674.5
Missouri	7,530.0	2,278.1	Hawaii	174.6	39.5
Montana	4,690.5	1,538.9			
Nebraska	5,468.3	3,628.0	Total	188,857.2	78,096.6
Nevada	1,541.0	1,081.6			

TABLE 17.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1929*

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
Alabama	$4,293,128.01	$2,072,634.60	183.5	68.2	251.7
Arizona	1,364,000.35	892,597.99	66.1	24.0	90.1
Arkansas	2,741,801.31	1,325,478.27	108.7	----------	108.7
California	6,650,687.38	3,228,015.10	171.7	9.3	181.0
Colorado	5,105,451.40	2,593,610.46	175.1	14.8	189.9
Connecticut	2,181,298.64	606,132.05	22.8	.1	22.9
Delaware	678,062.40	198,900.72	13.4	3.9	17.3
Florida	2,643,407.24	1,125,163.19	63.6	----------	63.6
Georgia	2,956,121.78	1,332,729.37	113.6	45.2	158.8
Idaho	2,435,074.59	1,441,742.26	150.8	66.5	217.3
Illinois	6,121,046.35	2,794,215.01	203.2	----------	203.2
Indiana	6,412,238.71	2,988,535.95	203.1	3.5	206.6
Iowa	7,457,609.97	3,382,766.29	123.1	170.5	293.6
Kansas	5,335,022.24	2,378,160.82	338.6	22.9	361.5
Kentucky	3,749,994.06	1,830,900.22	169.0	----------	169.0
Louisiana	1,240,120.23	611,432.56	46.5	----------	46.5
Maine	1,583,052.78	649,921.57	51.8	----------	51.8
Maryland	1,847,190.79	815,265.86	70.5	10.8	81.3
Massachusetts	3,087,998.38	1,064,911.57	69.7	.2	69.9
Michigan	5,940,513.07	2,405,266.86	153.8	.3	154.1
Minnesota	8,303,728.19	2,879,041.58	257.0	117.9	374.9
Mississippi	1,750,251.06	866,977.76	109.5	30.9	140.4
Missouri	3,922,393.41	1,545,883.79	99.6	64.2	163.8
Montana	2,836,700.85	1,834,170.77	244.2	13.4	257.6
Nebraska	4,434,167.82	2,140,403.77	460.2	182.5	642.7
Nevada	1,313,310.42	1,120,157.11	147.0	60.8	207.8
New Hampshire	1,001,020.85	409,954.34	28.1	----------	28.1
New Jersey	2,847,737.45	659,548.27	44.4	----------	44.4
New Mexico	2,229,501.77	1,467,188.58	137.6	5.6	143.2
New York	17,998,988.48	5,030,321.47	318.9	8.5	327.4
North Carolina	3,347,608.32	1,558,571.88	125.6	25.6	151.2
North Dakota	2,965,387.55	1,358,653.48	500.6	331.3	831.9
Ohio	7,216,174.12	2,876,713.72	201.2	12.1	213.3
Oklahoma	5,303,528.87	2,391,756.26	233.3	44.0	277.3
Oregon	1,776,270.44	922,764.06	43.0	----------	43.0
Pennsylvania	12,453,120.64	3,958,562.36	250.0	----------	250.0
Rhode Island	1,637,611.43	479,326.40	29.0	----------	29.0
South Carolina	5,493,642.34	1,289,919.53	98.8	90.3	189.1

TABLE 17.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1929*—Continued

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
South Dakota	$2,526,718.82	$1,345,451.61	450.7	125.1	575.8
Tennessee	5,010,358.01	2,231,811.60	72.8	118.6	191.4
Texas	9,233,596.56	4,016,467.80	235.3	197.2	432.5
Utah	1,331,229.22	963,406.50	99.8	29.8	129.6
Vermont	1,174,278.93	418,215.18	27.6		27.6
Virginia	2,501,862.94	1,108,813.98	84.8	6.3	91.1
Washington	2,095,070.15	872,594.07	76.7	5.0	81.7
West Virginia	2,287,197.12	1,071,351.56	94.1		94.1
Wisconsin	5,057,896.17	2,804,171.88	211.0	35.8	246.8
Wyoming	2,063,080.42	1,285,898.27	219.6	42.6	262.2
Hawaii	361,916.22	90,400.62	3.3		3.3
Total	195,298,168.25	82,736,878.92	7,402.3	1,987.7	9,390.0

TABLE 18.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, under construction on June 30, 1929, by States*

State	Estimated total cost	Federal-aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$3,258,926.95	$1,627,437.04	224.7	21.0	245.7
Arizona	2,199,816.28	1,859,989.34	100.5	30.1	130.6
Arkansas	3,656,725.36	1,799,403.14	102.9	6.5	109.4
California	9,612,659.34	4,324,210.30	265.4	9.9	275.3
Colorado	3,993,909.55	2,068,568.40	128.8	26.6	155.4
Connecticut	792,275.72	217,937.99	12.5		12.5
Delaware	753,366.80	298,843.42	15.7		15.7
Florida	2,734,529.08	1,135,234.01	90.9	5.7	96.6
Georgia	3,757,836.66	1,673,267.89	163.9	36.9	200.8
Idaho	905,547.56	542,064.66	77.5		77.5
Illinois	19,245,292.23	8,620,190.39	572.8		572.8
Indiana	8,958,464.70	4,278,868.78	275.9		275.9
Iowa	3,527,407.02	1,582,809.17	53.4	82.3	135.7
Kansas	3,432,075.07	1,346,245.56	243.8		243.8
Kentucky	4,598,602.22	2,194,672.33	243.8	3.4	247.2
Louisiana	3,623,495.55	1,803,989.15	151.9		151.9
Maine	1,883,862.41	646,104.12	44.3		44.3
Maryland	167,810.00	62,360.00	3.6		3.6
Massachusetts	5,097,641.63	1,538,226.50	91.1		91.1
Michigan	10,224,762.17	4,374,874.40	251.3		251.3
Minnesota	4,888,903.63	1,671,618.27	197.6	93.4	291.0
Mississippi	4,736,296.26	2,130,632.99	196.4	17.4	213.8
Missouri	9,068,176.63	3,483,757.97	211.8	56.2	268.0
Montana	5,089,960.81	3,187,267.45	354.2	8.1	362.3
Nebraska	2,892,184.38	1,438,788.31	240.5	60.2	300.7
Nevada	1,144,050.62	1,002,938.37	114.5	112.4	226.9
New Hampshire	561,177.02	198,553.31	12.5	1.0	13.5
New Jersey	4,565,550.60	815,205.00	54.3		54.3
New Mexico	2,261,247.93	1,429,503.15	137.6		137.6
New York	23,451,671.43	5,137,430.55	343.6		343.6
North Carolina	1,375,152.61	687,576.28	80.4	7.2	87.6
North Dakota	3,234,518.96	1,329,006.06	482.5	138.2	620.7
Ohio	11,976,628.49	4,206,990.80	257.2		257.2
Oklahoma	1,499,899.94	668,725.70	78.8	5.8	84.6
Oregon	793,251.14	391,848.56	48.2		48.2
Pennsylvania	12,854,654.57	3,395,873.25	202.5	14.1	216.6
Rhode Island	1,562,040.98	403,211.55	23.9		23.9
South Carolina	4,080,278.30	823,426.61	128.9	37.4	166.3
South Dakota	3,727,628.20	2,010,354.66	488.6	47.7	536.3
Tennessee	3,605,466.41	1,672,582.01	119.8		119.8
Texas	17,723,807.68	7,610,655.50	657.9	253.2	911.1
Utah	1,727,297.51	1,165,860.46	68.0		68.0
Vermont	1,889,278.37	632,504.02	38.1		38.1
Virginia	2,754,082.68	1,196,688.51	95.3	18.9	114.2
Washington	3,721,579.95	1,238,875.25	73.1	18.1	91.2
West Virginia	2,842,654.78	1,149,762.08	68.9	17.8	86.7
Wisconsin	9,777,590.68	4,308,468.14	307.1	29.3	336.4
Wyoming	1,526,197.61	979,518.74	155.1	8.9	164.0
Hawaii	402,261.10	137,426.82	6.6		6.6
Total	238,158,495.57	96,500,346.96	8,358.6	1,167.7	9,526.3

TABLE 19.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, approved for construction, as of June 30, 1929, by States*

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$430,398.21	$215,199.10	6.4	14.3	20.7
Arizona	226,598.57	170,606.04		29.4	29.4
Arkansas	529,229.73	262,782.41	25.3	6.0	31.3
California	2,536,332.71	1,117,206.50	31.6	19.5	51.1
Colorado	770,144.32	412,855.91	25.8	12.4	38.2
Connecticut	1,372,239.99	559,118.95	8.0		8.0
Delaware	535,184.40	262,260.69	30.8		30.8
Georgia	37,129.17	18,192.86	2.9		2.9
Idaho	202,122.35	121,880.16	16.3		16.3
Illinois	648,000.00	324,000.00	22.5		22.5
Indiana	1,058,051.61	504,631.00	35.3		35.3
Iowa	2,464,679.61	998,305.35	25.7	63.9	89.6
Kansas	2,067,844.93	981,277.15	135.9	11.5	147.4
Kentucky	463,762.16	231,833.31	40.3		40.3
Louisiana	287,899.05	105,752.71	.2	8.2	8.4
Maine	941,331.71	381,984.35	29.7		29.7
Maryland	980,260.95	456,710.00	39.3	16.8	56.1
Massachusetts	258,186.27	75,125.87	1.9	3.4	5.3
Michigan	2,155,000.00	933,716.86	51.6	9.5	61.1
Minnesota	1,498,509.36	416,297.96	74.7	16.6	91.3
Mississippi	188,293.15	94,146.56	12.9		12.9
Missouri	3,342,376.38	1,279,693.85	16.5	91.4	107.9
Montana	1,758,524.56	967,070.97	166.0		166.0
Nebraska	1,558,312.11	711,443.12	54.0	134.7	188.7
Nevada	334,482.30	297,187.45	.6	92.4	93.0
New Hampshire	252,935.68	97,410.00	6.5		6.5
New Jersey	521,240.38	130,335.00	8.7		8.7
New Mexico	241,716.29	154,094.12	9.0		9.0
New York	9,105,046.33	2,054,505.00	137.5		137.5
North Carolina	272,103.36	131,967.67	14.2		14.2
North Dakota	1,143,646.71	429,101.68	124.7	231.9	356.6
Ohio	4,310,036.60	997,860.29	59.7	19.3	79.0
Oklahoma	1,392,362.75	617,562.37	38.4	17.1	55.5
Oregon	1,137,687.38	708,004.14	72.9	44.8	117.7
Pennsylvania	3,619,350.36	1,267,978.20	81.9		81.9
Rhode Island	70,170.40	22,755.00	1.5		1.5
South Carolina	368,829.54	85,000.00	14.2		14.2
South Dakota	440,580.75	232,278.85	49.0	28.6	77.6
Tennessee	342,937.22	171,468.59	15.9		15.9
Texas	7,000,086.00	2,998,213.00	173.2	139.1	312.3
Utah	246,869.73	182,643.58	18.4		18.4
Vermont	20,051.36	10,025.68	.1		.1
Virginia	476,187.94	201,193.99	22.1	3.1	25.2
Washington	1,039,326.93	480,000.00	21.9	11.7	33.6
West Virginia	1,323,627.44	515,302.72	24.8	12.3	37.1
Wisconsin	754,725.77	363,097.16	38.9		38.9
Wyoming	213,573.07	140,210.67	28.7	27.4	56.1
Hawaii	562,688.38	247,259.61	16.6		16.6
Total	61,500,673.97	24,137,546.45	1,833.0	1,065.3	2,898.3

TABLE 20.—*Mileage of Federal-aid roads improved as of June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	143.0	534.1	912.5	11.6	74.1	87.6	189.9		7.9	1,960.7
Arizona	181.0	101.1	426.4	14.2	13.6	38.1	109.4		4.1	887.9
Arkansas	64.5	3.0	1,118.5	48.3	109.1	256.3	139.0		6.4	1,745.1
California	337.7		398.4	24.1	95.6	165.1	596.9		7.8	1,625.6
Colorado	232.4	96.2	480.8	5.3		13.0	298.8		10.9	1,137.4
Connecticut			.2	17.4	28.7	.6	178.5		3.9	229.3
Delaware				4.9	7.0	13.7	180.6	6.2	.5	212.9
Florida	9.2	15.5		131.1	78.9	53.6	143.2	10.1	7.4	449.0
Georgia	217.4	1,178.1	390.7	144.2	151.8	43.1	411.5	.5	27.3	2,564.6
Idaho	201.6	6.0	760.7	22.5	20.7	85.0	44.6		3.4	1,144.5
Illinois	153.7		.4		3.3	8.1	1,695.0	25.8	2.3	1,888.6
Indiana	16.5		42.2	41.6	23.4	12.0	1,120.3	6.6	4.1	1,266.7
Iowa	1,329.0		616.6				1,039.6	21.9	2.0	3,009.1
Kansas	1,033.6	280.5	236.2	4.5	125.5	3.4	678.8	163.3	13.6	2,539.4
Kentucky	625.3		253.8	41.3	201.9	14.6	170.4	3.9	3.3	1,314.5
Louisiana	30.6		1,194.0	3.2	9.5	33.5	39.9		10.7	1,321.4
Maine			214.8	8.6	167.6		88.9		.6	480.5
Maryland	4.7		31.5	1.2	235.7	22.1	332.7			627.9
Massachusetts			.5	6.6	308.6	59.5	191.5		4.0	570.7
Michigan	10.5		358.3	16.3	10.4	69.5	1,002.8	.4	2.0	1,470.2
Minnesota	852.2	6.2	2,261.5			32.7	718.6		1.4	3,872.6
Mississippi	233.5	16.7	1,158.3	11.1	1.5	10.4	208.0	9.7	7.3	1,656.5
Missouri	387.5	2.6	796.6	3.0	44.8	17.7	994.9	20.9	10.1	2,278.1
Montana	224.1	5.6	1,240.1	15.9	6.8	5.6	36.0		4.8	1,538.9
Nebraska	566.1	2,129.1	812.3		1.5	14.2	77.0	19.6	8.2	3,628.0
Nevada	51.2	9.7	833.4	14.9	122.5	2.0	45.2		2.7	1,081.6
New Hampshire			99.2	70.0	92.4	32.4	34.6		4.1	332.7
New Jersey	8.9		5.6			22.3	423.5		2.3	462.6
New Mexico	273.1	5.1	1,503.2			.7	81.9		4.1	1,868.1
New York	21.6	4.6	58.4		361.7	12.6	1,721.2	.7	1.9	2,182.7
North Carolina	103.8	459.7	63.6	19.6	37.9	249.5	774.6		3.2	1,711.9
North Dakota	1,344.1		2,313.4	5.4		1.9	4.7		7.0	3,676.5
Ohio	104.0		7.9	143.1	400.5	97.3	757.0	500.1	3.2	2,013.1
Oklahoma	416.1	2.3	605.6	6.3	49.5	102.2	620.5	8.9	12.3	1,823.7
Oregon	155.0		799.1	25.6	11.5	52.9	99.9		3.9	1,147.9
Pennsylvania	137.9				18.4	101.1	1,786.9	26.4	2.2	2,072.9
Rhode Island				1.8	44.2	49.7	69.4		.1	165.2
South Carolina	25.3	1,236.4	123.0	8.9	10.7	154.4	237.4	.2	17.4	1,813.7
South Dakota	264.5	35.0	2,996.9		4.0		7.2		3.2	3,310.8
Tennessee	67.2		123.8	52.3	428.7	40.5	431.3		4.6	1,148.4
Texas	567.2	90.4	2,937.9	518.8	886.3	137.2	883.8	29.2	13.3	6,064.1
Utah	105.3	40.8	607.0	23.8	29.7	9.9	99.5		2.3	918.3
Vermont			101.9	8.2	51.6		60.8		6.5	229.0
Virginia	55.1	203.4	116.2	107.2	357.9	13.7	487.7		4.3	1,345.5
Washington	171.0		371.6				307.5		4.3	854.4
West Virginia	272.6	3.9	25.4	4.8	170.8	22.9	170.0	11.4	1.5	683.3
Wisconsin	146.3	84.0	1,011.1	6.7	13.8	.5	791.3		2.4	2,056.1
Wyoming	523.3	483.3	581.6	21.4	21.2	22.1	15.9		5.7	1,674.5
Hawaii					11.5	8.6	19.0		.4	39.5
Total	11,667.6	7,033.3	28,991.1	1,615.7	4,844.8	2,193.8	20,617.6	865.8	266.9	78,096.6

TABLE 21.—*Mileage of Federal-aid roads initially completed during the fiscal year 1929, by types of construction, by States* [1]

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	77.5	8.1	64.5			0.1	31.2		2.1	183.5
Arizona	64.5	−14.6	12.0			3.0	.4		.8	66.1
Arkansas	53.1		34.4				18.3		2.9	108.7
California	19.1		50.6	4.9	31.0	25.1	39.0		2.0	171.7
Colorado	29.2		62.0	5.3			74.7		3.9	175.1
Connecticut					1.6		19.6		1.6	22.8
Delaware							13.4			13.4
Florida	.2		15.7	15.9		11.7	19.8		.3	63.6
Georgia	23.3	17.1	.1	37.1	7.5	16.3	12.0		.2	113.6
Idaho	16.6		119.9			5.6	8.3		.4	150.8
Illinois	43.4						158.9		.9	203.2
Indiana	3.0						199.7		.4	203.1
Iowa	−3.2		22.4				103.7		.2	123.1
Kansas	180.2	63.5	6.4		11.6		66.4	9.4	1.1	338.6
Kentucky	106.7		7.8		19.7	13.5	20.2		1.1	169.0
Louisiana	5.0		21.8				17.1		2.6	46.5
Maine			22.8	8.5	10.5		9.8		.2	51.8
Maryland					40.2	5.1	25.2			70.5
Massachusetts			.1	3.1	49.3	9.0	8.4		−.2	69.7
Michigan			8.3	.1			145.3		.1	153.8
Minnesota	182.8						73.6		.6	257.0
Mississippi	34.2		74.5		.6	.9	−2.3		1.6	109.5
Missouri	47.3	2.6	1.6				47.3		.8	99.6
Montana	15.4		225.5	−1.9			4.0		1.2	244.2
Nebraska	114.3	341.9				.4	2.1		1.5	460.2
Nevada	8.3		111.1		27.3		.3			147.0
New Hampshire				3.8	4.3		21.0		−1.0	28.1
New Jersey			.9			.4	43.1			44.4
New Mexico	34.1		91.3				11.0		1.2	137.6
New York	8.7		20.5		3.3		286.2		.2	318.9
North Carolina	15.1						110.1		.4	125.6
North Dakota	365.6	3.0	131.6						.4	500.6
Ohio	44.9		1.2	8.1	32.5	3.4	75.6	34.5	1.0	201.2
Oklahoma	156.3				26.5		49.7		.8	233.3
Oregon	16.4		14.9		10.7				1.0	43.0
Pennsylvania	47.8						200.6		1.6	250.0
Rhode Island					18.9	2.5	7.5		.1	29.0
South Carolina		27.2	13.9			15.9	38.4		3.4	98.8
South Dakota	97.3	9.3	343.6						.5	450.7
Tennessee	28.7				−.1	7.0	35.1		2.1	72.8
Texas	114.4		12.8	−.1	4.0		101.8		2.4	235.3
Utah	10.5		74.6		6.7		7.9		.1	99.8
Vermont			5.5		5.9		16.1		.1	27.6
Virginia		10.9			55.0	3.1	15.3		.5	84.8
Washington	30.2		27.5				18.8		.2	76.7
West Virginia	57.6		5.5		11.1		19.7		.2	94.1
Wisconsin	−1.3	9.5	93.9			.4	107.4		1.1	211.0
Wyoming	150.9		56.3	.2	11.4				.8	219.6
Hawaii					−8.7	8.6	3.2		.2	3.3
Total	2,198.1	478.5	1,755.5	85.0	380.8	132.0	2,284.9	43.9	43.6	7,402.3

[1] Net decreases in mileage of certain types due to abandonment and revision of plans indicated by minus sign.

TABLE 22.—*Mileage of Federal-aid roads under initial construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	168.2		38.3				16.6		1.6	224.7
Arizona	98.4				0.8				1.3	100.5
Arkansas	28.5		37.3			4.2	30.6		2.3	102.9
California	53.7		56.0		79.0	29.0	46.2	0.1	1.4	265.4
Colorado	9.4		75.3		10.8		32.3		1.0	128.8
Connecticut					10.9		1.6			12.5
Delaware				8.0			7.7			15.7
Florida	38.7			16.1	7.1		28.0		1.0	90.9
Georgia	29.0	6.9			70.7		57.0		.3	163.9
Idaho	5.4		56.5		15.5				.1	77.5
Illinois	62.8		1.0				500.9	6.2	1.9	572.8
Indiana	12.8						262.7		.4	275.9
Iowa			5.0				48.4			53.4
Kansas	210.8	.2	3.5		4.5		22.4		2.4	243.8
Kentucky	181.4		19.5		25.7		16.1		1.1	243.8
Louisiana	44.6		105.0						2.3	151.9
Maine			2.0	16.2	9.6		15.4		1.1	44.3
Maryland							3.5		.1	3.6
Massachusetts					72.8	11.7	6.3		.3	91.1
Michigan	24.7		29.7				195.0		1.9	251.3
Minnesota	196.9						.3		.4	197.6
Mississippi	90.1		60.6				41.2		4.5	196.4
Missouri	111.6	4.4					93.7		2.1	211.8
Montana	5.8		321.2		26.2				1.0	354.2
Nebraska	106.5	119.1			9.5		4.6		.8	240.5
Nevada			108.2		6.3					114.5
New Hampshire				.6	1.9		10.0			12.5
New Jersey	4.6		.9		.4	.4	48.0			54.3
New Mexico	36.6		39.3	22.3	36.8		1.1		1.5	137.6
New York	22.8		10.8		57.0		253.0			343.6
North Carolina		32.4	17.0				30.7		.3	80.4
North Dakota	386.9		76.9	17.3					1.4	482.5
Ohio	41.5		8.5	3.4	30.3	1.9	140.9	28.7	2.0	257.2
Oklahoma	64.5						13.7		.6	78.8
Oregon	44.2				3.5				.5	48.2
Pennsylvania	10.6						178.2	13.2	.5	202.5
Rhode Island					13.3	4.1	6.4		.1	23.9
South Carolina	28.9	44.8				1.5	52.9		.8	128.9
South Dakota	340.3	16.8	130.4				.3		.8	488.6
Tennessee	84.4						33.3		2.1	119.8
Texas	495.8		14.1	11.2		17.3	111.9	1.0	6.6	657.9
Utah	39.1		23.4	3.5			1.8		.2	68.0
Vermont			.3				37.4		.4	38.1
Virginia	30.2	12.6	18.7		16.9	8.4	7.6		.9	95.3
Washington	49.9		22.7						.5	73.1
West Virginia	35.1	3.3			13.7		16.5		.3	68.9
Wisconsin	1.4		87.5				216.1		2.1	307.1
Wyoming	149.1		5.5						.5	155.1
Hawaii	1.7				4.8				.1	6.6
Total	3,346.9	240.5	1,375.1	98.6	528.0	78.5	2,590.3	49.2	51.5	8,358.6

TABLE 23.—*Mileage of Federal-aid roads approved for initial construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama							6.4			6.4
Arkansas	6.6		8.2				10.4		0.1	25.3
California	9.3		4.1		13.9		3.4		.9	31.6
Colorado			18.3		7.5					25.8
Connecticut				0.6			6.0		1.4	8.0
Delaware			4.8				26.0			30.8
Georgia				.6	2.3					2.9
Idaho	3.6		12.7							16.3
Illinois							22.5			22.5
Indiana							35.3			35.3
Iowa	.3						25.4			25.7
Kansas	130.3						5.1		.5	135.9
Kentucky	27.9		6.4		5.9				.1	40.3
Louisiana									.2	.2
Maine			10.8	2.0	12.2		4.7			29.7
Maryland							39.3			39.3
Massachusetts							1.9			1.9
Michigan							51.5		.1	51.6
Minnesota	64.1		10.6							74.7
Mississippi	12.7								.2	12.9
Missouri	1.2						15.3			16.5
Montana	48.2		111.0		6.2				.6	166.0
Nebraska	11.3	36.6					6.0		.1	54.0
Nevada					.6					.6
New Hampshire							6.5			6.5
New Jersey							8.7			8.7
New Mexico			9.0							9.0
New York	22.1				23.2		92.2			137.5
North Carolina			9.1			0.9	4.2			14.2
North Dakota	122.3	.6	1.0				.8			124.7
Ohio	12.2						47.1		.4	59.7
Oklahoma	11.1					4.9	22.1		.3	38.4
Oregon	39.6		13.1		19.8				.4	72.9
Pennsylvania	5.6						76.3			81.9
Rhode Island							1.5			1.5
South Carolina							14.2			14.2
South Dakota	29.9		19.0						.1	49.0
Tennessee	15.9									15.9
Texas	109.1					.9	60.4		2.8	173.2
Utah	2.2		16.2							18.4
Vermont									.1	.1
Virginia	1.6		3.7				16.8			22.1
Washington	4.2		11.9				5.8			21.9
West Virginia					9.9		14.6		.3	24.8
Wisconsin	10.0		9.9				19.0			38.9
Wyoming	28.7									28.7
Hawaii					16.6					16.6
Total	730.0	37.2	279.8	3.2	118.1	6.7	649.4		8.6	1,833.0

TABLE 24.—*Mileage of Federal-aid stage construction completed during the fiscal year 1929, by types of construction, by States*[1]

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama		1.3					66.9			68.2
Arizona	5.9		—4.3		13.6	8.5			0.3	24.0
Arkansas	2.8			0.6	1.0		4.9			9.3
Colorado						9.1	4.7		1.0	14.8
Connecticut									.1	.1
Delaware								3.9		3.9
Georgia				20.1	10.0		15.0		.1	45.2
Idaho			51.4		15.1					66.5
Indiana							3.5			3.5
Iowa			20.5				150.0			170.5
Kansas	.6						22.3			22.9
Maryland					7.2		3.6			10.8
Massachusetts									.2	.2
Michigan									.3	.3
Minnesota	73.0						44.9			117.9
Mississippi			6.6				24.3			30.9
Missouri	—2.7						66.8		.1	64.2
Montana			10.5			2.9				13.4
Nebraska	.2	179.0			1.5		1.6		.2	182.5
Nevada				—13.9	74.7					60.8
New Mexico			5.1						.5	5.6
New York							8.5			8.5
North Carolina		4.0					21.6			25.6
North Dakota	4.5		326.8							331.3
Ohio					.1		11.8		.2	12.1
Oklahoma					—7.7	23.6	28.1			44.0
South Carolina					7.7	35.9	46.7			90.3
South Dakota			116.6		4.0		4.5			125.1
Tennessee							118.6			118.6
Texas	8.2		8.1	14.2	12.0		154.4		.3	197.2
Utah			.5	7.0	22.3					29.8
Virginia							6.3			6.3
Washington			.1				4.9			5.0
Wisconsin							35.7		.1	35.8
Wyoming			27.1	5.6	9.8				.1	42.6
Total	92.5	184.3	569.0	[1]33.6	171.3	80.0	849.6	3.9	3.5	1,987.7

[1] Net decreases in mileage of certain types due to abandonment and revision of plans indicated by minus sign.

TABLE 25.—*Mileage of Federal-aid roads under stage construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitumi-nous mac-adam	Bitumi-nous concrete	Portland cement concrete	Bridges	Total
Alabama	21.0								21.0
Arizona	15.9				14.0			0.2	30.1
Arkansas							6.2	.3	6.5
California							9.2	.7	9.9
Colorado				15.0			10.4	1.2	26.6
Florida					5.4			.3	5.7
Georgia			7.8		15.2		13.9		36.9
Iowa			15.2				67.1		82.3
Kentucky					3.4				3.4
Minnesota	11.2						82.2		93.4
Mississippi	13.0		3.2				1.1	.1	17.4
Missouri	10.9						45.1	.2	56.2
Montana			3.3	4.1				.7	8.1
Nebraska		59.9						.3	60.2
Nevada					112.4				112.4
New Hampshire							1.0		1.0
North Carolina							7.2		7.2
North Dakota	20.0		102.1	15.7			.4		138.2
Oklahoma							5.8		5.8
Pennsylvania							14.1		14.1
South Carolina						22.2	15.1	.1	37.4
South Dakota	25.2		3.0		5.5		13.9	.1	47.7
Texas					82.4		170.4	.4	253.2
Virginia						15.1	3.7	.1	18.9
Washington	18.1								18.1
West Virginia			15.3				2.5		17.8
Wisconsin							28.8	.5	29.3
Wyoming	8.9								8.9
Total	144.2	59.9	149.9	34.8	238.3	37.3	498.1	5.2	1,167.7

TABLE 26.—*Mileage of Federal-aid roads approved for stage construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitumi-nous mac-adam	Bitumi-nous concrete	Portland cement concrete	Bridges	Total
Alabama							14.3		14.3
Arizona	28.9				0.5				29.4
Arkansas							6.0		6.0
California	7.3		3.9				8.3		19.5
Colorado				6.6	5.8				12.4
Iowa							63.9		63.9
Kansas	1.5						10.0		11.5
Louisiana							8.2		8.2
Maryland							16.8		16.8
Massachusetts							2.7	0.7	3.4
Michigan							9.5		9.5
Minnesota							16.6		16.6
Missouri							91.4		91.4
Nebraska		115.3	1.9				17.5		134.7
Nevada					92.4				92.4
North Dakota			222.0	9.9					231.9
Ohio							19.2	.1	19.3
Oklahoma						6.6	10.5		17.1
Oregon					44.6			.2	44.8
South Dakota	1.2		27.4						28.6
Texas	9.2		12.6				117.2	.1	139.1
Virginia							3.1		3.1
Washington			11.7						11.7
West Virginia							12.3		12.3
Wyoming			10.3		17.1				27.4
Total	48.1	115.3	289.8	16.5	160.4	6.6	427.5	1.1	1,065.3

TABLE 27.—*Net changes in the types of Federal-aid improvements on the Federal-aid highway system during the fiscal year 1929* [1]

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	77.3	9.4	25.7			0.1	98.1		2.1	212.7
Arizona	56.3	−14.7	−31.8		13.6	11.5	.5		1.1	36.5
Arkansas	53.2		−3.8		−3.1		18.1		2.5	66.9
California	21.9		41.4	5.4	31.9	23.5	43.9		2.0	170.0
Colorado	6.2		54.3	5.3		9.0	79.4		3.9	158.1
Connecticut					1.7		19.6		1.5	22.8
Delaware				−.1			13.4	3.9		17.2
Florida	.2	−.2	−69.8	101.3		11.6	19.8		.3	63.2
Georgia	6.9	4.8	−22.9	57.3	17.5	16.3	27.1		.2	107.2
Idaho	16.4	−7.9	168.7		15.8	5.7	8.3		.4	207.4
Illinois	43.4				−.1		159.0		.9	203.2
Indiana	3.0						203.1		.5	206.6
Iowa	−126.6		50.4				253.6	−.1	.3	177.6
Kansas	156.3	63.5	6.4		11.6	−.1	88.8	9.4	1.2	337.1
Kentucky	103.3		7.7		19.7	13.6	20.2		1.1	165.6
Louisiana	5.0		20.7				17.1		2.6	45.4
Maine			22.8	8.6	10.4		9.8		.2	51.8
Maryland				1.0	35.6	5.1	28.7			70.4
Massachusetts			.1	3.1	49.4	9.0	8.4		−.4	69.6
Michigan	.1		−6.2	−2.6		−3.9	145.1		.4	132.9
Minnesota	195.8		−260.8				113.1		.7	48.8
Mississippi	21.1	.1	76.8		.5	.9	21.9		1.6	122.9
Missouri	12.2	2.6	−48.1	−4.4	−6.0		110.8		.9	68.0
Montana	4.6		229.1	−1.9	−.1	2.8	4.1		1.0	239.6
Nebraska	89.3	516.7	−16.2		1.5	.4	2.4		1.7	595.8
Nevada	−.2	−4.3	−20.9	−13.9	101.9		.3		.1	63.0
New Hampshire				3.8	3.8	−.5	20.9		−.9	27.1
New Jersey			.9			.4	43.0			44.3
New Mexico	28.9		86.6				11.0		1.3	127.8
New York	8.7		11.9		3.4		293.7		.2	317.9
North Carolina	15.1	−10.2	−7.3				131.6		.4	129.6
North Dakota	84.5	−21.8	457.9	.1						520.7
Ohio	39.0		1.2	8.0	32.6	3.4	87.3	34.6	1.1	207.2
Oklahoma	113.0				18.7	23.6	77.9		.8	234.0
Oregon	16.3		14.9		10.8				1.0	43.0
Pennsylvania	33.7					−.1	200.7		1.6	235.9
Rhode Island					19.0	2.5	7.5			29.0
South Carolina	.1	26.3	7.6		7.7	51.8	85.2		3.5	182.2
South Dakota	40.4	9.3	417.7		4.0		4.5		.5	476.4
Tennessee	−89.9			.1	−.1	7.0	153.6		2.1	72.8
Texas	−138.2	−.1	−48.9	10.4	16.0		256.2	.1	2.7	98.2
Utah	10.6	−.9	58.1	7.0	29.0		7.9		.1	111.8
Vermont			5.5		6.0		16.1		.1	27.7
Virginia	.1	11.0	−3.7	−5.1	51.3	3.1	21.5		.5	78.7
Washington	25.3		27.6				23.6		.2	76.7
West Virginia	45.2		5.5	−.1	11.1	−5.3	19.8		.2	76.4
Wisconsin	−62.3	−20.4	−31.1	−.1	.1	.5	121.5		1.0	9.2
Wyoming	140.1	−.8	64.8	5.9	21.2				.9	232.1
Hawaii					−8.8	8.6	3.2		.3	3.3
Total	1,056.3	562.4	1,292.8	189.1	527.6	200.5	3,101.3	47.9	44.4	7,022.3

[1] Net decreases in mileage of certain types due to abandonment and revision of plans indicated by minus sign.

TABLE 28.—*Federal-aid apportionment, and amounts paid to the States for the fiscal year 1929, and the unobligated balance of the total apportionment on June 30, 1929*

State	Apportionment fiscal year 1929	Paid to States during the fiscal year 1929	Unobligated balances of total apportionment on June 30, 1929
Alabama	$1,547,483.00	$1,627,208.67	$2,243,381.25
Arizona	1,059,081.00	1,309,267.51	2,653,890.02
Arkansas	1,281,785.00	1,377,002.44	2,104,522.21
California	2,486,415.00	3,433,055.14	821,207.18
Colorado	1,383,401.00	1,803,610.66	1,673,794.83
Connecticut	474,213.00	1,059,461.12	558,722.80
Delaware	365,625.00	142,185.23	47,336.16
Florida	901,311.00	894,258.16	1,965,926.62
Georgia	1,980,015.00	1,446,496.98	2,018,492.49
Idaho	932,962.00	1,270,906.07	856,815.71
Illinois	3,135,225.00	5,682,636.43	2,642,000.00
Indiana	1,921,463.00	2,374,265.04	134,519.81
Iowa	2,035,291.00	2,704,154.16	
Kansas	2,062,196.00	2,005,221.08	1,144,315.96
Kentucky	1,421,029.00	1,504,667.75	757,788.11
Louisiana	1,019,282.00	886,011.42	1,150,105.07
Maine	681,431.00	229,792.30	1,111,122.42
Maryland	634,906.00	712,060.20	213,725.37
Massachusetts	1,088,808.00	825,636.10	1,787,319.03
Michigan	2,209,596.00	3,090,670.12	1,424,179.67
Minnesota	2,112,595.00	2,216,048.53	410,000.00
Mississippi	1,309,729.00	1,306,196.99	1,361,970.25
Missouri	2,404,347.00	2,422,487.79	136,556.02
Montana	1,552,576.00	1,923,168.90	3,613,761.84
Nebraska	1,584,981.00	1,225,896.80	2,539,681.66
Nevada	957,995.00	863,467.12	204,689.18
New Hampshire	365,625.00	365,278.82	188,125.54
New Jersey	935,122.00	768,902.44	625,470.08
New Mexico	1,189,361.00	2,106,513.24	1,153,455.48
New York	3,629,879.00	3,761,689.93	4,295,740.58
North Carolina	1,715,910.00	1,716,874.85	1,721,786.21
North Dakota	1,193,440.00	1,325,962.17	982,621.03
Ohio	2,757,964.00	3,937,359.91	2,755,365.68
Oklahoma	1,749,066.00	1,614,336.80	913,425.83
Oregon	1,189,707.00	544,205.11	1,430,698.62
Pennsylvania	3,333,786.00	3,801,073.14	1,855,478.52
Rhode Island	365,625.00	402,771.00	548,347.68
South Carolina	1,059,533.00	816,484.11	886,629.83
South Dakota	1,223,981.00	1,107,488.48	371,595.94
Tennessee	1,612,012.00	2,245,874.99	1,096,306.59
Texas	4,502,576.00	4,191,191.70	36,517.80
Utah	848,093.00	1,066,011.51	361,621.97
Vermont	365,625.00	406,248.51	62,786.68
Virginia	1,437,548.00	1,297,653.57	758,318.82
Washington	1,143,226.00	1,498,282.57	917,100.03
West Virginia	793,796.00	1,090,621.80	77,371.86
Wisconsin	1,864,212.00	2,438,786.46	338,759.36
Wyoming	939,547.00	1,165,778.45	313,862.69
Hawaii	365,625.00	92,158.11	1,072,664.16
Total	73,125,000.00	82,097,380.38	56,339,874.64

NATIONAL FOREST ROAD CONSTRUCTION

In the forest road system there are 14,165.7 miles, of which 12,014.5 miles are in the States of the mountain and Pacific groups and Alaska. All appropriations for forest roads are expended upon this system.

As shown by Table 29, the mileage of class 1 highways, upon which it is planned to expend approximately 70 per cent of each annual appropriation until they are completed, is now 1,144.4 miles, of which 822.6 miles are in the Western States. These are the more important highways which are necessary sections or extensions of the Federal-aid system wholly within the forest areas. The class 2 highways which also extend the Federal-aid system, are increased by recent additions to a total of 7,256.6 miles, of which 7,018.5 miles are in the West. The class 3 highways, those that serve principally the communities within the forests now aggregate 5,764.7 miles, of which 4,173.4 miles are in the Western States and Alaska.

TABLE 29.—*Classified mileage of forest highway system, by States*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Western:				
Alaska			378.8	378.8
Arizona	174.0	491.0	243.0	908.0
California	321.5	989.6	784.9	2,096.0
Colorado		1,228.0	495.0	1,723.0
Idaho		738.1	351.1	1,089.2
Montana	147.4	657.2	381.0	1,185.6
Nevada		376.4	97.0	473.4
New Mexico	115.0	211.0	199.0	525.0
Oregon	58.0	872.4	441.0	1,371.4
South Dakota	2.0	169.0	63.0	234.0
Utah		458.0	299.0	757.0
Washington	4.7	472.8	311.6	789.1
Wyoming		355.0	129.0	484.0
Total	822.6	7,018.5	4,173.4	12,014.5
Eastern:				
Alabama			41.0	41.0
Arkansas	131.0	51.0	20.0	202.0
Florida		.7	106.0	106.7
Georgia			99.0	99.0
Maine			11.0	11.0
Michigan		13.4	55.0	68.4
Minnesota	41.0	38.5	142.0	221.5
Nebraska			28.8	28.8
New Hampshire	18.3	15.5	56.5	90.3
North Carolina	49.0		199.0	248.0
Oklahoma			33.0	33.0
Pennsylvania	24.5		173.0	197.5
South Carolina		6.0	40.0	46.0
Tennessee	58.0	71.0	169.0	298.0
Virginia		38.0	269.0	307.0
West Virginia		4.0	149.0	153.0
Total	321.8	238.1	1,591.3	2,151.2
Grand total	1,144.4	7,256.6	5,764.7	14,165.7

As shown by Table 30, the improvement of 315.4 miles of forest highways of all classes was completed during the year. Of this total 298.1 miles were in the Western States and Alaska, and the remaining 17.3 miles were in the forests of two Eastern States.

The total mileage upon which improvements have been completed to date, including the results of the last year's work, is 4,090.7 miles, of which 3,782 miles are in the West and 308.7 miles in the East.

TABLE 30.—*Mileage of completed forest highway projects, by States*

State	Mileage of forest highway projects completed.		State	Mileage of forest highway projects completed.	
	During 1929	Total to June 30, 1929		During 1929	Total to June 30, 1929
Western:			Eastern:		
Alaska	19.6	204.5	Alabama		5.1
Arizona	46.7	307.9	Arkansas	3.1	59.8
California	32.8	316.9	Florida		64.2
Colorado	23.8	332.2	Georgia		21.4
Idaho	21.9	484.3	Michigan		8.1
Montana	2.6	367.2	Minnesota	14.2	48.8
Nevada	2.8	110.8	New Hampshire		3.6
New Mexico	17.5	188.1	North Carolina		36.3
Oregon	73.2	647.1	South Carolina		16.0
South Dakota	1.5	46.2	Tennessee		33.5
Utah	15.9	300.9	Virginia		11.9
Washington	19.9	215.9			
Wyoming	19.9	260.0	Total	17.3	308.7
Total	298.1	3,782.0	Grand total	315.4	4,090.7

Although the mileage upon which improvements were completed during the year exceeds the mileage completed during the preceding year by more that 12 per cent, the increase is incidental rather than the result of any enlargement of the construction program. The latter is limited by the amount of the annual appropriations authorized, which have been unchanged for several years.

The policy of restricting the greater part of the expenditure to the improvement of the major roads within the forests is in accord with the similar policy which has yielded such satisfactory results in the improvement of the State roads. But even when so restricted the sums available annually for forest-road construction do not permit the improvement of the system at a rate consistent with the improvement of the roads outside the forest areas. With less than a third of the system improved to any degree, and much that has been improved in need of further improvement, it will be many years before the entire system can be adequately constructed at the present rate, and meanwhile the inadequacy of the forest roads will be thrown into sharper relief by the rapidly improving condition of the Federal-aid and State roads with which they connect. Under the present circumstances the most that can be done to serve the increasing traffic upon a large portion of the mileage is to keep the roads passable by maintenance, and this will be done. But increased appropriations are urgently needed if the roads through the forest areas are to be prevented from becoming serious obstacles in the path of a rapidly increasing traffic.

Among the more important improvements completed during the fiscal year are sections of the Johnson Pass, Point Agassiz, and Texas Creek highways in Alaska; the Pine-Long Valley highway in Arizona; the Howard Road in Arkansas; the Bear Valley, Idyllwild, Quincy-Beckwith, and Truckee-Myers highways, and the San Marcos extension in California; the Eagle-Thomasville, Mount Evans, and Ward-Raymond highways, and the road from Nederland to State route 26 in Colorado; the Enarville-Murray project, and the Lewis and Clark, Sawtooth Park, and Victor-Irwin highways in Idaho; the Grand Marais-Gunflint, and Winnibigoshish Dam-Bena Road projects in Minnesota; and in Montana the Clark Fork and Columbia Falls-Glacier Park projects.

In Nevada the Glenbrook-Spooners section of the Glenbrook highway has been completed; and in New Mexico a section of the Datil-Reserve-Dry Creek project. Also completed are sections of the Canyon City-Burns, Heppner-Spray, John Day-Pilot Rock, Mount Hood-Wapinitia and Salmon River highways in Oregon; the Deadwood-Custer-Hot Springs highways in South Dakota; the mountain section of the Vernal-Manila highway in Utah; the Metaline and Tonasket-San Poil highways in Washington; and the Dayton-Kane, Encampment-Slater, Granite Creek-Shell, and Jackson Park highways in Wyoming.

The construction of a number of important bridges was also completed during the year. Among these may be mentioned a railroad overpass on the Truckee-Myers project in California; the bridges on the Pritchard section of the Enarville-Murray project in Idaho, and in the same State the Sinclair Bridge and its approaches, and the Ketchum-Clayton Bridge; the bridge over Hell Roaring Creek on the West Gallatin project and the bridges on the Saltese section of the Yellowstone Trail in Montana; and in Washington the Sullivan Creek bridges on the Metaline highway.

Additional work involving surfacing and in some cases reconstruction was completed on the following projects: In Alaska, the Moose Pass, Salmon River, Tongass, Glacier, and Petersburg highways; in Arizona, the Main-Grand Canyon Highway; in California, the Truckee-Myers Highway; in Colorado, the Berthoud Pass Highway; in Montana, several sections of the West Gallatin Highway and the Y. G. B. Line Highway; in New Mexico, the Cimarron-Taos, Navajo Canyon, Alpine Reserve, and Canoncito-Pecos highways; in Oregon, the John Day-Pilot Rock, Klamath Falls-Lakeview, Santiam, and Oregon Caves highways; in Utah, the Cedar-Long Valley, and Heber-Fruitland projects; in Washington, the Lake Chelan extension; and in Wyoming, the Teton Pass section of the Teton Highway.

ROAD CONSTRUCTION IN THE NATIONAL PARKS

In the national parks where the bureau is supervising the improvement of the more important roads under an agreement with the National Park Service of the Department of the Interior, the year's work brought to completion the improvement of 100.7 miles

of park roadway, increasing the total thus far improved to 213.4 miles. At the close of the year construction was in progress on 113 miles and surveys were under way on 209 miles more.

This work is directed toward the eventual improvement of a system of major park roads in which there are now included 1,509.7 miles. The mileage included in the system and the parks within which it is located, together with the record of completion during the last year and to date, are shown in Table 31.

TABLE 31.—*The program of national-park road improvement, and the mileage of roads improved under the supervision of the Bureau of Public Roads*

National park	Mileage of the program	Mileage completed under the supervision of the bureau	
		During the fiscal year 1929	Total to June 30, 1929
Crater Lake	70.5	3.8	21.4
Glacier	145.9	24.6	30.2
Mount Rainier	122.1	2.2	14.0
Grand Canyon	156.7	25.6	33.9
Yosemite	218.6	.5	27.9
Sequoia	84.5	4.3	23.2
General Grant			4.0
Lassen Volcanic	39.5	7.8	13.6
Rocky Mountain	64.4	6.9	8.7
Devil's Tower National Monument	1.6		.3
Yellowstone	369.2	20.4	20.4
Zion	22.4	4.6	4.6
Hawaii	83.6		11.2
Mesa Verde	47.3		
Acadia	4.5		
Wind Cave	5.4		
Mount McKinley	73.5		
Total	1,509.7	100.7	213.4

Of outstanding interest among the projects completed during the year are the East Rim Road in Zion Park, and the west side section of the Transmountain Highway in Glacier Park. Both of these projects involved construction of an exceptionally difficult order. In the 4.6-mile length of the former there is more than a mile of tunnel; in the latter the road is hewn out of the rock face of the famous Garden Wall.

Both are of great importance aside from their value as means of developing and giving access to previously isolated portions of the parks. The Zion Park road is a link in the new route which will eventually connect the railhead at Cedar City, Utah, with the north rim of the Grand Canyon in Arizona, and thence by way of the House Rock Valley and the new Lees Ferry Bridge with the Arizona road system south of the canyon. The Transmountain Highway, as its name implies, will connect the two sides of Glacier Park and the adjoining country hitherto separated by the impassable mountain wall.

Other important projects brought to completion during the year are the Anna Springs-Crater Lake Highway in Crater Lake Park; the Babb section of the Babb-Many Glacier Highway in Glacier Park; the Grand View section of the Grand Canyon-Grand View Road, the south entrance road, and the Village and Yacqui Point spur roads in Grand Canyon Park; the southwest entrance and summit sections in Lassen Volcanic Park; the White River section of the Yakima Park Road in Mount Rainier Park; the Bear Lake project in Rocky Mountain Park; three sections of the General's Highway in Sequoia Park; and in Yellowstone Park, the Gibbon Canyon and West Gallatin roads and a section of the Sylvan Lake-Lake Butte Road.

RESTORATION OF FLOOD-DAMAGED ROADS IN SEVERAL STATES

In the agricultural appropriation act for the fiscal year 1929, approved May 16, 1928, appropriation was made as a contribution in aid from the United States for the relief of the States of Vermont, New Hampshire, and Kentucky which suffered serious loss through the damage and destruction of roads and bridges by the floods of 1927. The act provided that the sums appropriated should be expended by the State highway departments of the respective States with the approval of the Secretary of Agriculture for the restoration of the roads and bridges damaged or destroyed, in such manner as to give the largest measure of permanent relief. To obtain the benefit of the Federal appropriation the three States were required by the act to appropriate from State funds an amount equal to the contribution of the Government.

A similar appropriation was made by the War Department appropriation act for the fiscal year 1930, approved February 28, 1929, for the relief of

the States of Missouri, Arkansas, Louisiana, and Mississippi in consideration of the damage to roads and bridges caused by the heavy flood in the Mississippi River and its tributaries in the same year.

As required by these acts, rules and regulations for carrying out their purposes were promulgated by the Secretary of Agriculture, for the first mentioned on June 26, 1928, and for the second on April 19, 1929.

The several States have complied with the requirements of the two acts with respect to the appropriation of equal State funds; and the work of restoration is well advanced in Vermont, New Hampshire, and Kentucky. A considerable part of the money appropriated to each of these States has been obligated to definite projects and payments have been made in the amounts hereafter reported for work done. In the Mississippi Valley States the work was later in getting under way and no payments from Federal funds have yet been made.

The appropriations made for the relief of the several States were as follows: For the State of Vermont, $2,654,000; for the State of New Hampshire, $653,000; for the State of Kentucky, $1,889,994; and for the States of Missouri, Arkansas, Louisiana, and Mississippi, the total sum of $3,654,000.

The amounts of the respective appropriations obligated to definite projects up to the close of the fiscal year in Vermont, New Hampshire, and Kentucky, and the amounts paid to each on the basis of work completed are shown in Table 32. The mileage of roads improved in each of these States up to June 30, and the corresponding total costs and Federal payments are shown in Table 33. Similar information with regard to other projects under construction and approved at the end of the fiscal year is given in Tables 34 and 35; and the mileage of the several types of roads completed, under construction, and approved for construction on June 30 is shown in Table 36.

TABLE 32.—*Flood relief appropriated, amounts paid to the States, and the unobligated balance of the appropriation on June 30, 1929*

State	Appropriated	Paid to the States to June 30, 1929	Unobligated balance
Vermont	$2,654,000	$1,654,646.53	$144,976.30
New Hampshire	653,000	107,141.90	21,177.33
Kentucky	1,889,994	155,336.53	1,502,298.78
Total	5,196,994	1,917,124.96	1,668,452.41

TABLE 33.—*Total cost, flood relief, and mileage of roads improved to June 30, 1929*

State	Total cost	Flood relief	Mileage
Vermont	$1,742,883.88	$858,783.70	21.1
New Hampshire	632,045.58	316,022.75	7.7
Total	2,374,929.46	1,174,806.45	28.8

TABLE 34.—*Total cost, flood relief, and mileage of roads under construction on June 30, 1929*

State	Total cost	Flood relief	Mileage
Vermont	$3,621,056.92	$1,650,240.00	37.5
New Hampshire	540,988.06	270,494.01	14.2
Kentucky	652,990.48	326,495.22	29.2
Total	4,815,035.46	2,247,229.23	80.9

TABLE 35.—*Total cost, flood relief, and mileage of roads approved for construction on June 30, 1929*

State	Total cost	Flood relief	Mileage
New Hampshire	$91,211.82	$45,605.91	1.6
Kentucky	160,900.00	61,200.00	15.1
Total	252,111.82	106,805.91	16.7

TABLE 36.—*Mileage of the various types of flood relief roads completed, under construction, and approved for construction, June 30, 1929, in the States of Vermont, New Hampshire, and Kentucky*

Type of construction	Vermont			New Hampshire			Kentucky	
	Approved for construction	Under construction	Completed	Approved for construction	Under construction	Completed	Approved for construction	Under construction
Graded and drained							15.1	29.1
Gravel		3.3	3.8					
Water-bound macadam		9.1			4.9	2.9		
Bituminous macadam		3.6				2.3		
Portland cement concrete		17.4	15.0	1.6	9.2	1.9		
Bridges and approaches		4.1	2.3		.1	.6		.1
Total		37.5	21.1	1.6	14.2	7.7	15.1	29.2

MOUNT VERNON MEMORIAL HIGHWAY

As the fiscal year closed the detailed surveys for the Mount Vernon Memorial Highway had been completed and plans for all parts of the road were well advanced. Every possible effort is being put forth in the development of the plans to make this road one of the most attractive in North America. The alignment as designed is a succession of long, easy curves; the grades rise and fall gently with the natural roll of the hills; the cut and fill banks will be cut to flat slopes and rounded so as to merge with the natural topograph; and the bridges of which there are several, including an important highway grade separation structure at the south end of the present highway bridge over the Potomac, will be graceful flat arches faced with native stone.

Special attention has been given to the provision of adequate parking space at Mount Vernon and at several points along the way, and to features of design and location which will afford a maximum of safety at intersecting and entering roads.

Some delay has been experienced in the procurement of rights of way along the river location which was selected as the line to be followed; but it is anticipated that it will be possible to begin construction of the hydraulic fill along the river's edge at the north end early in the next fiscal year, and that properties that still remain to be acquired will be had in time to permit continuance of the construction without further delay.

It is the purpose to complete the highway by 1932 in order that it may be officially opened and dedicated as an incident of the celebration of the bicentennial of the birth of Washington in that year.

INTERNATIONAL ROAD CONGRESS AND PAN AMERICAN HIGHWAY ACTIVITY

In preparation for the Sixth International Road Congress, which, at the invitation of the United States Congress, is to be held at Washington from October 6 to 11, 1930, there is a great deal of preliminary work to be done, much of which necessarily devolves upon the bureau, and this work, including the preparation of advance notices of the congress, the nomination of American engineers to serve as reporters upon the various subjects proposed for discussion, the making of arrangements for transportation of foreign delegates by steamship and railroad lines, has already been begun.

This congress will bring to the United States a large number of the best-qualified highway engineers of foreign countries for a discussion of road problems of mutual interest and concern to all countries.

The Sixth International Conference of American States, at Habana, Cuba, by resolution adopted by the conference, recommended to the Pan American Congress of Highways, which will meet at Rio de Janeiro in August of the present year, the consideration and adoption of agreements looking to the construction of a Pan American highway connecting the continents of North, Central, and South America.

By joint resolution, approved May 4, 1928, the United States Congress, taking cognizance of the above-mentioned resolution, requested the President to direct the several agencies of

the Government to lend such cooperation and assistance as may be feasible and appropriate with a view to having the matter of the proposed highway thoroughly considered by the approaching Pan American Congress.

By another joint resolution, approved March 4, 1929, Congress authorized the appropriation of $50,000 to enable the Secretary of State to cooperate with the several governments, members of the Pan American Union, in reconnaissance surveys to develop the facts, and to report to Congress as to the feasibility of possible routes, the probable cost, the economic service, and such other information as will be pertinent to the building of an inter-American highway or highways. It is expected that this bureau will be called upon to assist in such a survey when it is undertaken; but, owing to the fact that the appropriation authorized was not made at the last session of Congress, no definite action has yet been taken in response to the resolution.

Subsequently, however, the President appointed representatives of the United States to the Pan American Congress of Highways, naming me, as Chief of the Bureau of Public Roads, as one of the representatives. In connection with this appointment, it has been necessary to give some preliminary study to the feasibility of the proposed highway and other matters of mutual interest to the countries of the two continents which will be considered at the forthcoming congress.

TRAFFIC SURVEY ON FEDERAL-AID HIGHWAY SYSTEM IN THE WESTERN STATES

As the fiscal year closed, agreements had been negotiated between the bureau and the States of Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Wyoming, Colorado, New Mexico, and Nebraska, providing for the cooperation of the several States and the bureau in a comprehensive and coordinated survey of traffic on the Federal-aid highway system within these States.

In the course of the survey, which will cover a period of a year, the usage of all parts of the system in these States, involving a total of more than 33,000 miles, will be determined by periodic counts of the number of vehicles of all classes passing survey stations located at suitable points. In addition to showing the volume of traffic on each section of the system, at all seasons of the year, the data to be collected will also indicate the points of origin and destination of the traffic, and in each State the proportion of intrastate to interstate traffic.

Of considerable sentimental interest will be the indications of the survey concerning the present traffic on the historic western trails. Data will be obtained along the full length of the Oregon Trail from Omaha to Portland, first traveled by pioneer wagon trains in 1843. Many of these old routes of pioneer travel are now followed closely by modern roads on which the long-distance bus has taken the place of the stage coach of former days. The routes from Omaha to Denver, Salt Lake City, and San Francisco; from Denver to Santa Fe and Los Angeles; and the Pacific coast route from Seattle to Los Angeles are among those upon which data relating to bus transportation will be obtained.

The improvement of these main roads of the Western States has now progressed to such an extent as to permit of the utilization of practically all parts of the system without insurmountable obstruction or serious inconvenience, so that it may be assumed that in the main the relative importance of the various routes has been established by their usage. The determination of the extent of usage of each route and section of route at this time will therefore provide information of great value to guide the further improvement of the system.

The data to be collected in regard to the origins and destinations of vehicles will serve to indicate the extent to which the system as at present designated fails to furnish facilities for direct movement from point to point, thus indicating the need for the addition of new routes. This type of data will also give information as to the usage of the roads of each State by vehicles registered in other States, thus providing a measure of the amount of tourist travel, a matter of considerable interest to the Western States.

STUDIES OF HIGHWAY PRODUCTION PROBLEMS

In this field the work of the past year which is worthy of special mention has dealt with four problems as follows: (1) Development and improvement of such means and methods of field operation as will permit the best possible utilization of the full

production capacity of the equipment and organization; (2) effect on rate of production and unit costs of certain rather common practices in present-day highway work; (3) the application of production engineering methods to low-cost bituminous construction; and (4) development, in cooperation with the various State highway departments, of a uniform standard outline for a system of fiscal records and cost accounting.

Modern road building is essentially a manufacturing process in which large arrays of movable plant and equipment instead of stationary factories are utilized to produce a finished product in permanent place on the right of way instead of in producing goods in a factory. As in much manufacturing work, the daily cost of operating a modern road-building plant is nearly independent of the rate of production. Consequently, the most effective way to decrease unit production costs is to increase the rate of production. Thus, the studies of the bureau show that the daily cost of operating a modern concrete-paving plant is about $400 per day whether the daily production of pavement be 500 or 1,000 feet. If the daily production is only 500 feet, the operating cost is 80 cents per lineal foot, whereas if production is 1,000 feet per day the operating cost is reduced to 40 cents per lineal foot.

The question thus becomes: How can this higher rate of production be attained and maintained without impairing the quality of the finished product? The answer is found (1) in eliminating or reducing the time losses and waste motions connected with all direct operations; (2) in coordinating and synchronizing the rate of production of the various subsidiary operations with the key equipment; and (3) in finding ways and means of eliminating unnecessary operations and of expediting those which are really necessary.

But before the highway industry can profit from this work of the bureau the ways and means devised must be applied to actual field conditions. For this reason the engineers of the bureau work almost entirely on selected, typical, going projects and in cooperation with the contractor, his superintendent, and the various highway officials in charge of the work. The maintenance of quality is always the first consideration. Nothing is permitted which might in any way reduce the quality below that called for in the contract. With the maintenance of quality established as the first essential, the conditions are studied and analyzed until the causes of the low production are located, when the study changes to devising ways and means for their reduction or elimination. As an example of the success which is often met in this work of reducing time losses and synchronizing operations, mention may be made of a concrete-pavement project during the past season in Wisconsin. The average rate of production on this project when the bureau's engineers began their studies was 134 square yards of pavement per hour. After the causes of the low rate of production had been located and ways for their reduction had been pointed out to the contractor and put into effect the rate of production rose to an average of 202 square yards per hour—an increase of slightly more than 50 per cent in the rate of production, with practically no increase in the daily cost of operation. Not all projects on which work has been done present the possibility of such great improvement. But very few projects have been found on which an increase of 10 per cent or more in the rate of production was not possible without any corresponding increase in the cost of operation.

The number of contractors with whom the bureau can cooperate directly in such demonstrations is, of course, limited. Those whose projects are analyzed have brought to their notice means by which their practice may be made more efficient, and almost invariably they welcome the bureau's suggestions and benefit by them not only on the particular project studied but also in other contracts which they subsequently obtain. But the benefits of this work extend far beyond the particular contractors and engineers with which the bureau cooperates directly. The several contractor's associations have manifested keen interest in the methods developed and the results obtained and through these associations the principles developed have been widely disseminated, thereby reaching and influencing the operations of an ever-widening circle of road builders. Engineers of the States and counties are apprised of the results of the studies through reports published in the bureau's journal of highway research, Public Roads, and by means of papers presented at national and local engineering meetings. In these ways the benefits of these studies have been widely extended, and the principles

and methods developed are being successfully applied by a large and increasing group of the most progressive and responsible contractors.

In road-grading work, solid rock, shale or hardpan is frequently encountered. Before materials of this character can be moved they must usually be blasted. Occasionally the blasting is such as to loosen and break up the material very well, but more often it is only sufficient to break the material into pieces too large to be readily handled by the power shovel. A study has recently been completed which shows that well-blasted rock or shale can be handled by a good power shovel about as fast as ordinary common excavation, but that poorly blasted rock reduces this average rate of operation by at least 30 per cent. In actual pay yardage as measured in the cut, the average decrease due to poor blasting is not less than 10 cubic yards per hour and may readily be three times as much. Furthermore, because of the excessive wear and tear on the equipment, the hourly operating cost of a power shovel is actually higher when working in poorly blasted material than when working in well-blasted material. Poor blasting, therefore, is at present a source of considerable direct and unnecessary expense to the grading contractor and to the taxpayer who must finally pay the cost. Naturally, the large extent of the loss has not been appreciated or the practice that causes it would not have been tolerated. The bureau will now undertake to bring about a correction of these practices by the various means that have been described above.

Attempts have been made during the past year to find effective ways and means of applying the principles of production engineering to the construction of low-cost bituminous roads. This type of construction is new and neither methods nor equipment have as yet attained any considerable degree of standardization. Some of the operations involved, such as the mixing of oil and stone particles in place on the road, present problems which have not arisen in connection with any other type of construction. Lacking equipment designed especially for the new purposes, available equipment intended for other purposes is being employed with obvious lack of efficiency. The bureau has undertaken a study of the problems presented by these new types of construction, and will endeavor to suggest means and equipment adapted to attain the ends sought with greater facility and economy than is at present possible.

During the past year the bureau has assisted several States in the installation of uniform accounting and statistical procedures designed to supply full and complete records of expenditures and accomplishments in the fields of highway construction, maintenance, and administration. Basically this work consists in making use of bookkeeping and tabulating machines and in the development of standard definitions of operations and of practices and the setting up of standardized accounts thereunder. Further developments of this work and adoption of such uniform systems of accounting by the several States will make possible comparison of the costs of construction and maintenance of roads as carried on in each of the States—a comparison which is not at present possible because of the dissimilar forms of records kept. Such comparisons when they can be accurately drawn will be helpful to all States as an index of the need for correction of their practice, and will be especially useful as a means of supplying data not now available with regard to the cost of maintaining the various types of roads under various conditions of traffic, climate, topography, and soil.

PHYSICAL RESEARCHES

SUBGRADE INVESTIGATIONS

In previous annual reports mention has been made of the subgrade investigations which have been carried on continuously for several years and which, on account of the fundamental nature of the problems involved, are considered as among the most important of the physical researches with which the bureau is concerned.

General experience and observation, supplemented by special investigations, have disclosed that the performance of road surfaces is greatly influenced by the stability of the subgrade, that is, its resistance to lateral flow under load; by volume changes in the subgrade material due to variations in moisture content; by its elastic properties; the degree of uniformity of the support which it furnishes; the occurrence of heaving due to frost action; and the presence or absence of certain chemical constituents.

The investigations which are being conducted have for their ultimate pur-

pose the determination of the physical laws governing the behavior of soils and the identification of the soil constituents which exert a major influence on behavior; the determination of the extent to which the characteristics of soils are influenced by their constituents and the extent to which they are influenced by the natural conditions in which the soils occur; the development and standardization of tests which will permit a laboratory identification of soils and the development of methods for identifying and mapping subgrade soils in the field; the classification or grouping of soils with respect to their efficiency as subgrades and the correlation of this grouping with the existing classification which has been developed for agricultural purposes; and the determination of methods for correcting undesirable subgrade conditions.

The procedure followed includes laboratory investigations of soils to learn the physical laws which govern stability, shrinkage, expansion, compressibility, elasticity, and heaving due to frost; and other laboratory investigations of the extent to which different tests disclose the physical characteristics of soils and permit the identification of the soil constituents upon which these characteristics depend. Closely correlated with these laboratory investigations there is a field examination of road failures involving variations in road type, character of soil and its moisture content, climate, and amount of traffic, recording for subsequent analysis the results furnished by these examinations with respect to type, design, age, and condition of road surface, drainage conditions, topography, the underlying soil profile, and the soil characteristics as disclosed by the laboratory tests. Similar observations are made of roads on which have been used such corrective measures as drainage improvements, subgrade treatments, and subbases; and the final stage will involve the construction and subsequent observation of experimental roads in which various corrective methods have been employed.

The investigations have been continued, as in the past, with the cooperation of the Bureau of Chemistry and Soils and various State highway departments and educational institutions.

The investigation of heaving due to frost action is illustrative of the manner in which the different problems are being attacked. It has been observed frequently that certain sections of pavement have heaved during cold weather to an extent much greater than can be explained by the expansion during freezing of the moisture originally present in the layer of frozen soil. In New Hampshire, with the cooperation of the State highway department and the Massachusetts Institute of Technology, observations of frost heaving have been made during the past two winters to determine climatic conditions, vertical displacement of the pavement, height of groundwater level, depth of frost penetration, and character of ice formation. Information regarding the character, condition, and arrangement of the underlying soil zones has also been obtained. In an extension of this study, designed to permit a better control of the variable factors, the behavior during freezing and thawing of New Hampshire soils, transported to the campus of the Massachusetts Institute of Technology, has been observed during one winter. These investigations have been supplemented at the University of South Carolina by controlled laboratory studies of the physical laws which control the growth of ice crystals during freezing, and at the Arlington Experiment Farm by observations of the rate of heat transfer through different types of pavements.

As a result of these studies it has been found that excessive heaving due to frost action is caused by segregation of the moisture as it freezes to form layers of solid ice, additional water, which is in turn frozen, being drawn up through the soil pores from the ground-water level below. Under conditions favorable to this action, very thick layers of ice may be formed. Much has been learned regarding the soil, moisture, and climatic conditions which promote the formation of these layers of ice and this knowledge suggests certain corrective measures which may be used to advantage.

The subgrade investigations are continuous in nature. Although definite accomplishments can now be reported, a vast amount of work remains to be done in the solution of the difficult problems which are encountered. During the year there has been published an instructive report summarizing much of the present knowledge of the subject and illustrating the possibilities of utilizing this knowledge as a

guide to the selection of proper pavement type and the proper design of the type selected.

LOW-COST BITUMINOUS ROAD INVESTIGATIONS

The investigations in the development of relatively inexpensive methods for the improvement of light-traffic roads are being continued and extended to meet the particular needs of various sections of the country.

An extensive inspection trip by two members of the bureau staff has been made through nine of the Western States for the purpose of observing the results which are being obtained in the oil treatment of crushed rock and gravel roads. As a result, arrangements have been made for the construction of two experimental roads, one in California and one in Nebraska.

As mentioned in the last annual report, these oil treatments have been used extensively in the Western States and with marked success. However, nearly all of this work has been done with light fuel oils and road oils and the experimental road in California is being built to study the possible utility of other materials such as asphaltic emulsions, asphaltic cements, and cut-back asphalts. The road will be about 10 miles long and will include 20 experimental sections. The work is being done in cooperation with the division of highways of the California Department of Public Works.

A considerable portion of Nebraska is included in what is known as the "sand-hill area," in which there exists very little satisfactory road-building material. The natural soil in this area is a fine-grained sand, lacking in binding material and entirely unsuited to road construction in its natural condition. Some treatment is necessary in order to produce a road surface adequate even for the comparatively light traffic of the region. Treatments of extremely sandy soils with bituminous materials have been successful elsewhere, notably in California, and some preliminary experimental construction of limited extent in Nebraska has given promising results. In order to develop the methods and materials most suitable for use in connection with the sandy soils of this area arrangements have been made for the construction of an experimental road about 9 miles long in cooperation with the Nebraska Department of Public Works.

In South Carolina the cooperation with the State Highway Department in the bituminous treatment of sand-clay and topsoil roads has been continued and extended. Twenty-eight miles of experimental highways already constructed are under observation and 4½ miles of bituminous surfacing on sand-clay and marl bases is under construction.

To supplement the intensive studies carried on by means of the above-mentioned experiments, extensive surveys are in progress in which the results of methods of construction developed by State and local highway officials in all parts of the United States will be studied and compared. The common object of all such methods is the production of a bituminous road surface of moderate cost which will adequately serve light and medium traffic; but various materials have been used and various methods of combining the bituminous and nonbituminous constituents have been developed.

By careful study of the methods and materials used in various parts of the country, by comparison of the results obtained, and by disseminating the information gathered it is expected that the better methods and materials will be more quickly adopted generally, and progress in the development of still better methods and materials will be accelerated. In these surveys the bureau is acting in cooperation with the Asphalt Association, representing practically the entire road-asphalt industry of the United States.

MOTOR-TRUCK IMPACT INVESTIGATIONS

The investigation, mentioned in the last annual report, of the effect on motor-truck impact of the use of resilient or cushion wheels has been completed and a report issued. The study was undertaken with the thought that new developments in wheel equipment might be as effective in reducing the impact of trucks on pavements as are improvements in tire equipment. The general conclusion which resulted is that resilient wheels may reduce impact reactions and that the reductions may be negligible or important, depending upon the construction of the wheel and the tire equipment used. The cushioning properties of resilient wheels are much more pronounced with solid tires than with pneumatic tires. The data obtained are of particular interest to those who are con-

cerned with the evaluation of the road damage resulting from the use of various types of motor-vehicle equipment.

The major activity during the past years, in connection with the impact investigations, has been the thorough study of the accuracy of the determination of impact forces by the methods which have been developed by the bureau. This study has been made in cooperation with the Bureau of Standards and has involved extensive work in the calibration of the instruments used. The results themselves are extremely technical in nature and will be of little general interest, but they will establish the degree of accuracy of a vast amount of data relative to the subject of the impact of motor vehicles on roads and will eliminate all questions regarding the instruments used in future investigations.

CONCRETE INVESTIGATIONS

One of the first and most important steps preparatory to building a concrete road is the selection of the materials of which the concrete is to be made and the determination of the proportions which must be used in order to produce concrete of the desired quality Pavement concrete differs from other manufactured products only in that it is manufactured at the place of use rather than in a mill or factory. A knowledge of the effect on its quality of variations in the amount and character of the constituent materials is as important to the highway engineer as is the accurate control of furnace operation to the steel manufacturer.

Until quite recently it has been commonly assumed that so long as the mineral aggregates were sound and reasonably hard the particular kind or character of aggregate employed would have little, if any, effect on the strength of the concrete. In this way such proportions as 1:2:4, 1:3:6, etc., indicating proportions by volume of cement, sand, and coarse aggregate, respectively, came to be rather generally accepted as indicating concrete of a definite class or quality. However, it is becoming more and more apparent, as the results of additional research become available, that the strength of concrete may be affected appreciably by the kind of coarse aggregate used. It has become evident that if concrete mixtures are to be designed intelligently consideration must be given to factors other than simple volumetric proportions.

One of the major investigations of concrete completed during the past year was an extensive series of tests to determine the effect of the kind or type of coarse aggregate on the strength of concrete. Seventeen different aggregates were used, of which 7 were crushed stone, 7 were gravel, and 3 were blast-furnace slag. The crushed stone ranged from a very hard, tough, trap rock to a soft limestone, while the gravels included the glacial types of the Northern States, sedimentary or limestone gravels, and those of the quartz varieties. Slags of three different degrees of density were used. Over 2,000 concrete specimens were made and tested in this investigation.

The results of the study showed that, other things being equal, a change in the type or kind of coarse aggregate used in the mixture may cause a very considerable change in the transverse strength of the concrete, in some cases as much as 30 per cent.

One of the aggregates chosen for study, a quartz gravel, when used in concrete of a 1:1.6:3 mix, gave an average modulus of rupture of 535 pounds per square inch, while a limestone gravel in concrete of the same proportions gave an average modulus of 650 pounds per square inch. In concrete of a 1:2:4½ mix the same materials gave average modulii of 420 and 520 pounds per square inch, respectively. The significant point of this comparison is the fact that the limestone gravel in the lean mix (1:2:4½), which required only 5 sacks of cement per cubic yard of concrete, produced concrete of practically the same strength as the concrete of the richer mix (1:1.6:3) containing the quartz gravel and requiring 6.6 bags of cement per cubic yard.

On the assumption that it is desired to build a concrete pavement of a certain definite strength, and that these two aggregates are both available and sell at approximately the same price, the use of the aggregate producing the higher strength would result in a saving, under normal price conditions, of at least $1,500 per mile of 18-foot roadway. This example illustrates the economic advantage of a definite knowledge of the factors which affect the quality of concrete and the ra-

tional application of this knowledge in the design of concrete mixtures.

The maximum amount of coarse aggregate which may be used in concrete mixtures without sacrifice of quality is another problem of importance. Other things being equal, the greater the proportion of solid stone or gravel in a unit volume of concrete, the greater is the durability of the product from the standpoint of resistance to weathering action. Also, as a general rule, an increase in the amount of coarse aggregate reduces the cost of the concrete since there is a relatively smaller use of cement, the most expensive element of concrete.

On account of the extra labor involved in the hand finishing of concrete containing a high percentage of coarse aggregate, the use in paving work of mixtures containing an excess of mortar has come into general favor even though such mixtures may not be the most economical from the standpoint of the cost of materials and even may be somewhat deficient in quality. The great advances which have been made in the development of mechanical equipment for concrete-pavement construction and the general adoption of this equipment, with the consequent reduction of hand labor, has made practicable the use of the harsher concretes which are produced when appreciable increases are made in the proportion of coarse aggregate. Thus, it becomes necessary to know the effect of increases in the amount of coarse aggregate on that most important quality, strength.

For the purpose of studying this problem an investigation has been started which involves the construction of a concrete pavement 9 feet in width and somewhat over a half mile in length. In the test sections of which this pavement will be composed various proportions of gravel, crushed stone, and blast-furnace slag are being used. In order that the results obtained may be representative of those which might be secured in regular paving work, the construction is being carried on with mechanical equipment of the latest design, including weighing batcher-plants for proportioning the materials, a full-size paving mixer, and finishing machines.

The pavement will not be subjected to traffic but will be cut into beams the flexural strength of which will be determined by testing. The investigation includes the placing of more than 600 cubic yards of concrete and the testing of about 5,000 specimens.

Previous work by the State Highway Commission of North Carolina has indicated that the amount of coarse aggregate commonly used in pavement concrete can be considerably increased without any appreciable reduction in strength. If these findings are corroborated by the present investigation a considerable economic advantage will result.

HIGHWAY-BRIDGE INVESTIGATION

In the construction program of the Port of New York Authority there are included a number of long-span bridges, the most notable of which is the Hudson River Bridge which will have a main span of 3,500 feet, the longest suspension bridge in the world at this time. Possible improvements in the quality of concrete used in the floor slabs of bridges and possible advantages to be gained by the use of lightweight concrete in the floors of long-span bridges are matters of general importance in the highway field and of immediate importance to the Port of New York Authority. The common interest in these problems led to a cooperative arrangement between the bureau and the Port of New York Authority under which an extensive series of tests is being conducted at the Arlington Experiment Farm.

The program involves the construction, with materials and methods such as might be used in the construction of bridge floors, of 22 concrete slabs, each 6 feet wide and 22 feet long. Different aggregates have been used, including one of light weight which resulted in a concrete weighing only about two-thirds as much as the ordinary product, and different vibratory methods were employed in placing the concrete for the purpose of increasing its density and thereby improving its quality. The large slabs were subsequently cut up into smaller pieces of sizes suitable for testing. The program includes tests to determine the strength of plain and reinforced slabs, the bond strength of embedded steel, and the density, durability, and elastic properties of the concrete. The testing work is approaching completion and it is indicated by the data thus far available that information of considerable value to highway engineers will

be obtained. It is anticipated that the results will be reported during the next fiscal year.

DIVISION OF AGRICULTURAL ENGINEERING

IRRIGATION INVESTIGATIONS

DUTY-OF-WATER STUDIES

A report covering the irrigation requirements of the Columbia River Basin has been submitted for publication, this being the fourth of a series of five publications dealing with the requirements of various large areas in the West. Studies of irrigation-water requirements in San Diego County, Calif., and of the economic duty of water in the Sacramento Valley, Calif., conducted in cooperation with the University of California, have been completed and reports will be published by the cooperating agency.

The cooperative investigation of the penetration and storage of rain falling upon valley floors in the Santa Ana River area in California is being continued. Soil samples have been taken regularly during selected periods from the "consumptive use of water" plots, which included citrus, walnuts, peaches, and brush, and laboratory determinations have been made of the moisture content. The experiments at Devil Canyon tunnels on rainfall penetration are being continued, but the measurements on rate of evaporation and transpiration losses from the river bed under field conditions were temporarily discontinued because the scant rainfall during the rainy season resulted in the drying up of Temescal Creek, the site of the study. During the year the Army air service in the territory made an airplane survey of the moist area, without cost to the Bureau of Public Roads. Near Santa Ana and San Bernardino daily evaporation and transpiration losses were measured and additional tanks installed in order to determine the effect, if any, of an oil film on the rate of evaporation from a free water surface.

Investigations to determine the consumptive use of water in the Sacramento-San Joaquin Delta have been carried on since 1924, under cooperative agreement with the State of California and the agricultural experiment station. The delta contains nearly a half-million acres approximately at sea level, and is traversed by a network of navigable channels. Even at low tide the water surface in the channels is higher than much of the land. About half the area has been reclaimed by the interposition of some 1,500 miles of levees. The interior of the region is mostly peat, 5 to 40 feet or more in depth. The outlying portions and strips along the natural channels are slightly higher and are currently classified as sedimentary. Water (usually in amounts greatly in excess of crop requirements) is drawn from the channels through culverts and siphons and by pumping. Drainage, consisting largely of excess admitted from the channels, is returned to them by pumping. The prevailing system of distribution is designed for subirrigation, but surface irrigation is practiced to some extent on sedimentary lands.

It is desirable that consumptive use of water be determined on large tracts bearing a variety of crops, on individual fields of single crops, and, as permitting the maximum of precision, on crop plants grown in soil tanks. The 23,000 acres of sedimentary land in the lower unit of reclamation district No. 999 present exceptionally favorable conditions for determining the use on a large tract. There is, however, a gravel stratum 30 feet and more below the ground surface, which connects with the water in the channels and gives rise to vertical seepage. On Medford Island, consisting of 1,200 acres of deep peat, the drainage withdrawal in the irrigation season was found to be almost equal to the amount of water admitted, indicating that almost enough water for the crops reached them by underground paths. The use of water on individual fields of single crops, on both peat and sedimentary lands, has been determined satisfactorily in some instances. The methods employed in growing crop plants in soil tanks are believed to duplicate almost completely the essentials of field conditions. By taking into account the factors which tend to make practical field irrigation relatively less efficient, the tank results may constitute a principal basis for the estimation of the proper share of the delta lands in the waters of the rivers. An additional pertinent use of the tanks is to determine the consumptive use by aquatic and other growths which present a material demand. Full-scale operations on sedimentary lands were suspended at the close of the season of 1928, but those on the peat lands are still in progress.

In connection with these investigations, a 60-inch steel siphon was rated

under conditions of full and partial vacuum, and a rod with electrical connections was devised for the precise observation of water levels in certain situations, as in tube wells, where the hook gage can not be used.

LOSS OF WATER BY EVAPORATION

The results of investigations during former seasons have been brought together in a report on evaporation from free-water surfaces, which will be submitted to authorities on the subject for review and criticism in the immediate future. Some studies are yet to be made on large reservoirs to check the formula derived as a result of former studies.

PUMPING FOR IRRIGATION

A bulletin on pumping for irrigation and drainage is in preparation. The bulletin will include a summary of methods and practices peculiar to certain representative districts in the West, a discussion of economic problems which limit the profitable utilization of pumping plants in irrigation practice, an outline of the procedure to be followed in determining whether or not a pumping venture may succeed, a description of the types of pumps and standard equipment and their uses, and a study of plant efficiency and power problems.

DESIGN, INVENTION, AND TESTING OF APPARATUS

The studies of design and behavior of various measuring devices and water-stage recording instruments have been continued. Some noteworthy progress has been made, especially in extending to very large dimensions the Venturi flume, developed by members of the Division of Agricultural Engineering. This has been adopted by the State engineers of two Western States as a standard device for the measurement of irrigation water where weirs and other calibration devices, because of topographic or other conditions, would be inaccurate. Studies have also been made of a new adjustable tube measuring device. Improvements have been made on the Hoff meter, and some new water-stage recording devices have been developed.

CONTROL OF GRAVEL AND SILT IN IRRIGATION CHANNELS AND RESERVOIRS

This investigation is now confined to the Texas field where, in cooperation with the State Board of Water Engineers, the silt-carrying capacity of several selected streams and rates of deposit in certain reservoirs are being studied. Daily water samples are taken during flood and normal water stages, and analyses are made of the silt content. A study of the movement of bed silt is also in progress. Due to the uncertainty of stream flow it is not possible to state at this time how long it will be necessary to continue these studies.

FLOW OF WATER IN DITCHES, PIPES, AND OTHER CONDUITS

The manuscript on the flow of water in riveted steel and analogous pipes has been submitted for publication. The study of the flow of water in flumes is being continued and will, in all probability, be presented in the form of a manuscript for publication during the coming fiscal year.

CUSTOMS, REGULATIONS, AND LAWS RELATING TO IRRIGATION

Studies begun during the fiscal year 1928 in cooperation with the Oregon Agricultural Experiment Station, involving the engineering, agricultural, and general economic status of various irrigation districts in Oregon, were continued at the invitation of the State Reclamation Commission. These districts, organized during the postwar period, received advances from the State to cover interest on their bonds for periods of one to five years, to enable the farms to be brought into profitable production before the usual payments for construction must begin. These advances originally were to be repaid after maturity of the bonds.

The purpose of the State's plan was not accomplished. Development was not speeded up; large portions of the lands are still untilled; and most of the districts have been unable to meet their obligations. Other elements of failure, such as faulty engineering, insufficient water, and mistakes of organization and management, have entered into the history of these districts, as they have elsewhere.

The studies involved 8 of the 14 districts assisted by the State. On the basis of the conditions disclosed a relief measure was enacted by the legislative assembly of 1929, by which the districts may be relieved of their obligations to the State in case the bondholders agree to readjust their claims on bases ascertained to be economically justifiable. Negotiations are now in progress between most of the

districts and the holders of their bonds to effect such settlements. At a previous session of the legislature a law was enacted, at the suggestion of the Division of Agricultural Engineering, which provides for the assessment of bond-principal obligations on a plan of individual rather than joint liability.

This investigation has involved a research into the causes of the distress of a group of districts that are representative of a great many such enterprises throughout the West. The lessons taught by the history of this group are to be discussed in a report for publication.

OTHER IRRIGATION ACTIVITIES

The studies of the reclamation of alkali land in cooperation with the Utah and Idaho experiment stations are being continued. The investigation naturally yields results very slowly. There is no hope of reaching any very definite conclusions as to the cost and feasibility of reclaiming alkali tracts during the coming fiscal year, but it is felt that progress has been made and that the study is well worth continuing.

A manuscript on the discharge of drains serving irrigated lands has been prepared during the fiscal year and will shortly be submitted for publication. Further studies of drainage methods, their efficiency, effectiveness, and cost are being carried on in New Mexico, Oregon, and Washington.

DRAINAGE INVESTIGATIONS

RUN-OFF MEASUREMENTS AND DITCH CAPACITIES

Continuing the studies of many preceding years to determine the necessary capacity of ditches and other works for land drainage, investigations were made relative to rates of run-off from 4 small hilly areas in Little River Drainage District in southeastern Missouri, from 10 areas in northeastern Indiana, and from 1 very small area in Iowa. Continuous records have been obtained of the flow in the channels draining these areas and of the rainfall upon each area, and careful descriptions of the size, shape, topography, soil, and vegetative covering of the areas have been prepared. Manuscript reports of run-off investigations in southern Illinois, in southeastern Arkansas, and in Bolivar and Washington Counties, Miss., have been completed.

Computations of the sizes of ditches that must be constructed to carry predetermined quantities of flow are based upon some formula that combines the various measurable hydraulic elements and an empirical resistance factor. Experiments to determine values of the roughness coefficient in the Kutter-Chezy formula for velocity of flow were made in connection with the run-off measurements in northeastern Indiana. Accurate measurements of discharge, water slope, and size of stream were made in different channels, and compiled with detailed descriptions of the condition of the waterway with respect to soil, vegetation, and accumulation of débris. Similar experiments were made on a large floodway covered with growing timber in northeastern Arkansas. A report showing the results of such measurements made in prior years in eight States, with recommended values to be used for the Kutter roughness coefficient under different conditions, is now in press.

SOIL-EROSION INVESTIGATIONS

The studies of rates of run-off and erosion from experimental plots near Raleigh, N. C., in cooperation with the State experiment station, have been continued. The appropriation act for the fiscal year 1929 provided a special fund to be expended by the Department in studying soil erosion and its prevention. The fund was allotted among the Bureau of Public Roads, the Bureau of Chemistry and Soils, and the Forest Service. In January, 1929, experiments were begun on a 160-acre farm near Guthrie, Okla., made available by the Guthrie Chamber of Commerce. Since then, 75 acres of that farm have been terraced with 7 miles of terraces; 63 dams of different types have been built and 1,800 feet of gullies have been filled with brush to check erosion; 15 acres have been partly cleared and grubbed; 60 acres have been planted in cotton, and 41 acres in various other crops. Additional experiments were begun in April, 1929, on a 140-acre farm near Temple, Tex., in cooperation with the State Agricultural Experiment Station. A survey and map of the farm have been made, and other preliminary work done. About 15 acres have been terraced, and planted in cotton.

The purpose of the soil-erosion investigations, which have been conducted, with slight interruption, since 1915, is to determine the most practicable means of preventing or reducing erosion of agricultural lands, by ter-

racing, by underdrainage, or by cultural methods.

Measurements are made and detailed data are collected relative to (1) the rate of movement of soil down different land slopes; (2) the design of terraces and terrace systems according to differences in soil types, land slopes, and rainfall distribution; (3) the rates of run-off and of soil erosion from terraced and unterraced fields; (4) the best methods of constructing terraces with different kinds of implements; (5) economical methods of maintaining the terraces in effective operation; (6) the effectiveness of terraces for conserving rainfall, by increasing the amount absorbed by the soil; (7) satisfactory methods of operating farm implements and machinery in terraced fields; (8) the proper design and construction of different types of soil-saving dams for checking erosion and reclaiming gullies; and (9) the effectiveness of different cover crops in reducing or preventing erosion, on terraced and on unterraced lands. Study of the effectiveness of deep plowing, subsoiling, and underdrainage in checking soil erosion is contemplated. On the farm near Temple studies of level, as well as of sloping terraces, will be made and crop yields on terraced and unterraced lands will be compared.

FLOW AROUND BRIDGE PIERS AND CHANNEL BENDS

Continuing studies, begun in 1928, on the obstruction of bridge piers to flow of water, approximately 980 experiments were made at the hydraulic laboratory of the University of Iowa. Twin piers were used, each 14 inches wide, in a testing canal 10 feet wide, with 7 combinations of nose and tail shapes. The effects of the piers in increasing the depth of water were measured for different depths and velocities of flow. The results were consistent with those obtained in 1928 and, like the latter, gave coefficients for various bridge-pier formulas that differed somewhat from those obtained by other experimenters. In regard to least deviation from the test data, the formulæ arranged themselves in the following order: Nagler, D'Aubuisson, Rehbock, and Weisbach.

It is believed, as a result of the experiments, that the erosion which occurs around the base of the up-stream end of piers is due to the downward component of the velocity of the water. For use in measuring these velocities, a self-contained instrument that combines a Pitot tube for measuring the velocity and a current-direction indicator for registering both horizontal and vertical angles has been designed, and some work on the manufacture of it has been done.

A report upon the effect of variations in direction and rapid changes in speed of flow upon the registration of current meters with rod suspension has been completed, giving the results of a large number of experiments on 11 types of current meters tested in very turbulent flow at the hydraulic laboratory of the University of Iowa.

A model of Des Moines River Valley at Ottumwa, Iowa, was constructed in the hydraulic laboratory, and tests were made to determine the probable effect of digging cut-offs across two large bends in the channel. The observed results on the model checked closely the results computed for the actual river channel. Construction and observation of the river cut-offs will yield data that are expected to be of material value in determining the general dependability of results obtained from models.

OPERATION AND MAINTENANCE OF PUMPING PLANTS

Something like 500,000 acres of bottom land along Illinois River and along the Mississippi between St. Louis and Savanna, Ill., are organized in districts that have constructed levees for flood protection and pumping plants for drainage, at an average cost exceeding $40 per acre. The annual operating costs for the pumping plants alone, including fixed charges, average probably $1.50 per acre. Most of these districts are in financial difficulty, and many land owners have lost their farms. Much of the pumping equipment is inadequate to give proper drainage, and is inefficiently operated.

For the purpose of analyzing the methods and costs of operating and maintaining these plants, records and tests on 15 plants have been obtained in the last few years. During the past year, as previously, record was made of rainfall, run-off pumped, frequency and duration of pumping, lift of water, amount of fuel or power used, and costs. Further tests of pump and overall efficiencies were made. The results emphasized certain conclusions previously stated, that efficiency is greatly increased and power cost reduced by adjusting the speed of the pumps to the lift of the water and by keeping the pumps, piping, and screens free of trash. Further, it was apparent,

cleaning of ditches leading to the pumps would give much more effective drainage in some districts. Third and fourth progress reports on this investigation have been prepared, giving the records and conditions of pumping at the districts under investigation during 1926 and 1927.

USE OF OPEN DITCHES AND TILE DRAINS

A manuscript for a Farmers' Bulletin on farm drainage has been prepared and is now being printed.

A report upon the economical use of large tile in land drainage has been prepared. This report compares the total costs of drainage by means of open ditches and the larger sizes of tile, including costs of maintenance as well as construction.

DRAIN-TILE MATERIALS

The experiments and tests of concrete drain tile and concrete cylinders in alkaline soils and waters have been continued, in cooperation with the University of Minnesota and the Minnesota Department of Drainage and Waters as before. The investigation has been broadened to include (1) studies of the resistance of concrete and of clay tile to acids found in peat, muck, and some other soil types, and (2) studies to develop, if possible, some reliable tests of the resistance of tile to frost action that can be made more readily than tests now prescribed by the American Society for Testing Materials.

EFFECT OF DRAINAGE ON FOREST GROWTH

A study of the reaction of swamp forests to drainage was made in northern Minnesota, in cooperation with the Forest Service and several State agencies. The report, published by the State commissioner of drainage and waters, shows an average increase in growth, due to drainage, of about one-fourth cord per year on the test plots. The forest types were black spruce, tamarack, and cedar.

FARM-LAND DEVELOPMENT

POISONING TREES AND STUMPS

Clearing land of trees and stumps by any means that the individual farm owner can employ is at best a slow and laborious process. Not the least part of the work is the repeated cutting of the sprouts that spring from the green stumps. Poisons applied to cuts in the trees have sometimes been effective in killing both tree and stump. Therefore investigation has been undertaken to determine the value of such treatment for different kinds of trees. Various poisonous compounds have been used at different seasons of the year, and the compounds have been injected into the trees and stumps by various methods. The experiments are being made in six Central and Eastern States. Examinations are made at intervals to note the rapidity with which the trees and the stumps die and decay. Some varieties of trees die quickly after being poisoned; but, thus far, pines and some other varieties seem to be affected very little.

CLEARING LAND OF BRUSH AND STONE

The removal of brush is a considerable part of the work of clearing farm lands in the Lake States. Investigation has been begun, in cooperation with the University of Minnesota, to determine the cost of clearing brush land by plowing, by pulling, by burning, and by cutting and poisoning. Tests are being made to determine whether the intense heat under burning brush piles injures the soil, and may be the cause of the sterile spots that are found in large numbers in some localities.

In certain parts of Minnesota great numbers of stones are scattered over the ground. It has been suggested that they are being brought to the surface continually by frost action, a condition which would require that those lands must be cleared of stone not once only, but periodically, if they are to be kept suited for cropping. Data are being collected to ascertain whether there is truth in the suggestion.

MECHANICAL FARM EQUIPMENT

CORN-BORER CONTROL

The development of mechanical devices for combating the European corn borer, and the testing of different kinds of farm machines in control work, have continued along the lines established in the preceding year. Over 60 plows, variously equipped, were tested for cornstalk coverage on several different soil types. Studies of plow-body shapes and beam clearances were included. A stationary low-cutting knife to harvest the whole stalk has been devised, with the appurtenant parts necessary for attaching and operating it on four prominent makes of corn binders. A stubble-slit-

ter attachment for a standard corn binder has been devised and is being tested. A simple sled-type 2-row stalk shaver has been developed, two of which with a 3-horse hitch may be used to cut four rows at a time. Tests of new and used husker shredders were made to determine the influence of various adjustments on the effectiveness of the machines in killing borers in infected stalks. Studies of equipment for heat treating the larvæ in the field were continued, but not completed. Tests have been made of poling and raking implements for collecting crop débris, and of the effectiveness of different baling pressures for destroying the borers, but additional study of these and other kinds of equipment are in progress.

FERTILIZER DISTRIBUTORS

Supplementing the laboratory investigations of the preceding year, field tests of 24 fertilizer distributors have been made to study the effect of different kinds, amounts, and placements of fertilizer on the germination, growth, and yield of cotton. The practicability of machines that both plant the seed and apply the fertilizer will be compared with that of separate machines for the two operations. Planting and fertilizing were done in the spring of 1929; yields will be measured in the fall. The tests were made in cooperation with the Bureau of Chemistry and Soils, the joint committee on fertilizer application, and Clemson Agricultural College and Experiment Station, S. C.

COTTON-DRYING EQUIPMENT

The cotton-drying unit constructed and tested in 1927 was tested again in 1928 with favorable results, and a manuscript has been prepared for a bulletin describing the construction and operation of this equipment. Some growers who observed the operation of the test unit are already installing like driers for treating their 1929 crop.

SUGAR-BEET MACHINERY

A preliminary study has been made of the machinery used and labor required for producing sugar beets, from preparation of the land for planting to delivery of the beets to the factory or railroad. Analysis of the data collected indicates that mechanical equipment can be utilized to perform a large part of the work now done by hand, and thus appreciably reduce the cost of production.

ARTIFICIAL DRYING OF HAY AND SMALL GRAIN

In the humid region, unfavorable weather conditions at hay-making time often result in improper curing of the hay, and sometimes practically total loss of the crop. Wherever hay is cured by drying in the field, even under favorable conditions, a considerable portion of the leaves, the most nutritious part of the plant, is lost by shattering in handling. Therefore, investigation of the practicability of artificial drying has been undertaken, in cooperation with the Bureau of Plant Industry and the Nebraska Agricultural Experiment Station. The purpose of the experiments in the fiscal year 1929 has been to discover the principles involved in removing water from hay. In the experimental apparatus, small quantities of green hay were reduced to a desirable moisture content in one and one-half to three hours, by evaporating about two-thirds the weight of the green hay. The cured product graded No. 1 extra leafy, valued then at $8 to $10 per ton higher than the ordinary grade. Development of drying equipment for general farm use has not yet been begun.

Since an excessive moisture content in grain is likely to cause damage in storage, experiments were begun to determine the practicability of artificial drying of wheat. In cooperation with the Bureau of Agricultural Economics, a small experimental drying outfit was set up and operated in 1928 at Fargo, N. Dak., to study the time and heat requirements for drying and to determine the effect of artificial drying upon the grain. It was found that the use of temperatures up to 160° F., the highest used, had no material effect upon germination or upon the milling and baking qualities. Further experimentation is required.

FARM STRUCTURES

DAIRY BARNS IN SOUTHEASTERN PENNSYLVANIA

Many old barns still structurally sound are not suited to production of milk in accordance with requirements set up by public health authorities in many of the larger cities. Particularly is this true of the bank type of barn very common in southeastern

Pennsylvania, owing to inadequate lighting and difficulties of ventilation. For the purpose of determining what changes are practicable in improving existing barns, or in replacing barns that have been destroyed by fire or other cause, in order that the milk produced may be marketed in the cities, an investigation of the dairy barns in southeastern Pennsylvania was made, in cooperation with the Interstate Milk Producers' Association of Philadelphia. The report of conditions found, with general recommendations, has been prepared.

HEATING OF GREENHOUSES

The operation of even a small commercial greenhouse is a matter of considerable expense, and the cost of heating is one of the principal items. Control of temperature is also one of the important factors in successful operation. Because there is little information available concerning this subject applicable to small greenhouses of the commercial type, a study of selected structures of this kind has been undertaken to determine, for such structures, the heating requirements as affected by climatic conditions, the best types of heating systems, the advantageous kinds of fuel and methods of firing, the effective and economical means of temperature regulation, and the proper basis of proportioning the heating system to the size and construction of the house. The investigation is not yet complete.

Laboratory experiments have been undertaken to determine the effect upon temperature distribution in cold-storage rooms, of different locations and arrangements of the cooling pipes, of different areas of the cooling surface, and of different temperatures of the refrigerant; and also to determine to what extent humidity can be controlled by proper arrangement, location, area, and temperature of the cooling surfaces. Collection of the data is still in progress.

SERVICE WORK

A considerable part of the time of the staff of the structures section during the past year has been required for designing barns, a greenhouse, a machine shop, an abbatoir, and other buildings, and preparing specifications for buildings and equipment for various other bureaus of the Department of Agriculture.

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

United States Department of Agriculture,
Bureau of Public Roads,
Washington, D. C., September 1, 1930.

Sir: I submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1930.

Respectfully,

Thomas H. MacDonald,
Chief of Bureau.

Hon. Arthur M. Hyde,
Secretary of Agriculture.

During the past fiscal year the Federal-aid road program was continued practically within the limits set by the $75,000,000 appropriation authorized for the year. Although the amount of the appropriation provided for each year since 1925 has been the same, it has been possible previously to carry on the work of road construction at a more rapid rate because of the availability of a balance of funds authorized and appropriated for the earlier years and not expended within the year for which they were intended.

This year the actual disbursement of Federal-aid funds was $75,880,863, but little more than the $73,125,000 apportioned to the States after deduction of the 2½ per cent allowed for administration from the authorized appropriation; and it was more than $6,000,000 below the expenditure of the preceding fiscal year.

Accordingly the mileage of initial improvements completed—7,317.4 miles—was less than that in any previous year since the rate of appropriation was fixed at $75,000,000.

In addition to the roads initially improved, advanced stages of construction were completed on 2,011.2 miles of roads previously improved with Federal aid; and 20.8 miles previously built were reconstructed.

At the close of the fiscal year initial improvements were under way on 7,709.2 miles and stage construction was in progress on 2,187.2 miles. There were also 18.4 miles previously built with Federal aid which were in course of reconstruction.

This is the first year in which it has been necessary to spend any part of the Federal appropriations for reconstruction, and the mileage involved is small, but as time goes on it must be expected to increase. It is now 12 years since the first Federal-aid roads were completed, and the ordinary life of some of the types of surface built does not exceed that term.

U S Dept. of Agriculture
Aug. 1, 1931

It is necessary to distinguish clearly between stage construction and reconstruction. The former represents a deliberate postponement of a stage of improvement known at the time to be necessary eventually to meet the needs of the foreseen traffic. The postponement is necessary by reason of the limitations of available funds and the desirability of spreading them over as great a mileage as possible consistent with the provision of a reasonable improvement of highway facilities.

The expenditure of Federal funds for reconstruction is authorized only where the type of construction originally provided was deemed adequate for the then present and probable future traffic requirements, but by reason of an unanticipated increase in traffic has proved to be inadequate. Before approval of further expenditure on such roads it must be satisfactorily established that there has been nothing lacking in their maintenance by the State, and it must be clearly apparent that the necessity for reconstruction results from the increased demands of traffic. It follows that all reconstruction approved must be of a higher type than the original construction.

The total mileage initially improved with Federal aid since 1917 is 86,978.6 miles. This mileage has been reduced by 696 miles by the replacement of certain roads improved prior to 1921 and not included in the designated Federal-aid system by a lesser mileage of more important roads in the system to which the original Federal investment has been transferred. It has been further reduced by 64.2 miles by relocations made in the course of stage construction; so that the actual present length of the roads initially improved with Federal aid and retained as Federal-aid highways is 86,218.4 miles. As 2,205.6 miles were under stage construction or reconstruction at the close of the year and had been temporarily removed from the classification of improved mileage, the total so classified on June 30, 1930, was 84,012.8 miles.

As a result of the increase in the appropriations authorized by Congress at the last session the rate of progress in the construction of Federal-aid roads may be expected to increase next year and in the years immediately following. For the fiscal years 1931, 1932, and 1933 the amounts authorized are $125,000,000, two-thirds greater than the $75,000,000 appropriations which have been the rule since 1925. Although the increase in the appropriation for the fiscal year 1931 was not apportioned until last April, the immediate response of the States resulted in the obligation of $102,498,084 to definite projects during the last fiscal year, as compared with $70,428,896 obligated during the fiscal year 1929. This higher rate of obligation will, of course, be followed in due course by a greater rate of completion of the improvements now undertaken, and the next year's completion of projects should be materially greater than that reported for this year.

The Federal-aid highway system, in which is included practically all of the mileage now classed as improved with Federal assistance, has been increased in size during the past year and now embraces 193,049 miles of main interstate and intercountry roads.

In addition to the improvements made possible by the Federal-aid appropriations, the bureau has also cooperated with a number of States in the restoration of roads damaged by floods in 1927 and

1929. This work, which is made possible by several special acts of Congress, has resulted to date in the completion of improvements on 57.8 miles of road in Vermont, 24.6 miles in New Hampshire, 39 miles in Kentucky, and 0.3 mile in Mississippi. To the latter State there has also been paid $341,702.91 for work completed prior to the passage of the flood relief act.

By the completion of 266.8 miles of national-forest roads during the year the total mileage upon which improvements have been completed was increased to 4,357.5 miles. Of this total, 4,026.7 miles are in the 12 Western States and the Territory of Alaska and 330.8 miles are in Eastern States. These improved roads are portions of the forest-road system which has been designated jointly by State and Federal authorities and which includes at present a total of 14,576.1 miles, of which 12,378.8 miles are in the States of the West and Alaska and the remainder in Eastern States.

The work done in cooperation with the National Park Service resulted during the year in the completion of 88.7 miles of important improvements in the parks, bringing the total mileage thus far improved to 302.1 miles, all included in the system of 1,509.7 miles of principal park roads which has been designated.

As in previous years, the bureau has continued to carry on, concurrently with the improvement of Federal-aid, forest, park, and other highways, a program of highway research planned to produce a more exact factual basis for the design of road systems and road structure suited to the expanding needs of modern highway traffic.

Of principal interest during the year were the survey of traffic on the Federal-aid system in the Western States, now nearing completion; the study of soils in respect to their usefulness and stability as road subgrades; the extensive studies and intensive experiments looking to the development of types of surface of low cost suitable for the large existing mileage of lightly traveled roads; the continuation of studies of the characteristics of concrete for road pavements and bridges; and the analyses of the possibilities of greater economy in construction operations, which also have been continued with increasingly useful results.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

Initial improvements were completed during the fiscal year on 7,317.4 miles of the Federal-aid highway system; advanced stages of construction were completed on 2,011.2 miles; and 20.8 miles previously improved were reconstructed. The total mileage upon which improvements were completed was therefore 9,349.4 miles.

At the close of the year construction of initial improvements was in progress on 7,709.2 miles, and other initial improvements had been approved for 1,940 miles. Stage construction was in progress on 2,187.2 miles already initially improved with Federal aid, and similar advanced improvements had been approved for 1,522 miles. In addition, 18.4 miles of roads previously improved were in process of reconstruction, and 7.3 miles were approved for reconstruction.

The mileage of initial improvements completed was less than the mileage of such improvements completed in any year since 1923 and

less than the mileage completed in the preceding fiscal year by 84.9 miles. The mileage of stage construction completed was greater than the mileage completed in any previous year except 1928, and greater than the mileage completed in the preceding year by 27.1 miles. In total mileage of initial and stage construction completed the year's record was lower than that of the preceding year and the lowest since 1924. The record of mileage completed in each fiscal year since 1923 is shown in Table 1.

TABLE 1.—*Mileage of initial and stage construction completed by fiscal years 1923–1930, inclusive*

Fiscal year	Mileage of initial construction completed	Stage construction completed		Mileage of total construction
		Mileage	Percentage of initial construction	
1923	8,820.2	117.8	1.3	8,938.0
1924	8,610.2	360.4	4.2	8,970.6
1925	11,320.3	556.4	4.9	11,876.7
1926	9,322.3	1,052.6	11.2	10,374.9
1927	8,289.4	1,712.6	20.6	10,002.0
1928	8,157.5	2,016.2	24.7	10,173.7
1929	7,402.3	1,984.1	26.8	9,386.4
1930	7,317.4	2,011.2	27.5	9,328.6

The decline in mileage completed was anticipated. It is the natural result of the contraction of the program to a $75,000,000 basis, necessitated by the authorization of that annual sum for several years and the final absorption of the unobligated balance of funds appropriated for the earlier years.

As the appropriations authorized for the fiscal years 1931 to 1933, inclusive, have been increased to $125,000,000, it may be confidently expected that the mileage completed in the ensuing years will be greater.

A year ago the total mileage that had been improved with Federal aid, less extra-system mileage replaced and mileage reductions resulting from relocations, was reported as 79,264.3 miles. A complete review of all records during the past year, resulting in minor corrections of the mileage of many of the earlier projects, shows that the exact total was 79,131.1 miles.

During the past year there have been further reductions by the replacement of mileage off the system amounting to 210.7 miles, and reductions by relocation amounting to 19.4 miles. Thus the addition of 7,317.4 miles of initial improvement during the year brings the total of mileage improved at the close of the year to 86,218.4 miles. With the exception of a very small mileage improved before 1921 and still retained, all of this mileage is in the Federal-aid highway system. As 2,205.6 miles of the above total was in course of stage construction or reconstruction when the fiscal year closed, the total mileage classified as improved with Federal aid at that time was 84,012.8, as shown in Tables 24 and 28.

STAGE CONSTRUCTION

As explained in previous reports the work designated as stage construction consists of the further improvement of roads previously improved to some degree with Federal aid. This work does not increase the mileage reported as improved with Federal aid. On the contrary, it may actually reduce the previously recorded mileage as a result of relocations found to be possible and desirable. As for several years past, a reduction of this sort is reported this year amounting to 19.4 miles.

Work is classed as stage construction only when it represents an advanced Federal-aid improvement of a road previously improved with Federal aid. The initial grant of Federal aid to a particular piece of road is not designated as stage construction, even though the road may have been previously improved to some degree by the State or other agency.

As the Federal-aid operations to date have resulted in the improvement of less than half of the Federal-aid system (although by the States or other agencies nearly the entire system is known to have been improved to some degree), there is still a very considerable mileage improvement of which with Federal aid will be classed as initial improvement. Nevertheless, as the improvement of the system progresses toward the standard ultimately to be desired and as more and more of the system receives Federal aid for its improvement, the mileage classed as stage construction may be expected to increase and to constitute an increasing percentage of the entire improvement operation.

This trend is clearly shown by Table 1, which shows that stage construction was completed during the past year on 2,011.2 miles, a mileage greater than that similarly improved in any previous year except 1928. The table also shows that the ratio of the amount of stage construction to the amount of initial construction completed during the year was 27.5 per cent, and that there has been a steady increase in this percentage since stage construction work was begun in 1923.

The effect of the stage construction from year to year is shown in the steadily increasing percentage of the higher-type improvements from year to year. Thus, at the close of the fiscal year 1926, the mileage improved with high-type pavements of block, concrete, and bituminous concrete was less than 26 per cent of the total improved mileage. Two years later it was a little less than 29 per cent. Last year it was 30.4 per cent; and to-day 33.2 per cent of the mileage classified as improved (exclusive of bridges) is paved with these highest types of surfacing. Nearly 45 per cent of the stage construction completed during the past year was of these types.

As in previous years, the mileage of stage construction completed is mainly in those sections of the country in which the large mileage of road remaining to be improved, the relatively sparse population, and limited funds, required, in the earlier years of work on the roads, a restriction of the initial improvement to grading and draining and the cheaper types of surface in order to spread the benefits of some measure of improvement as widely as possible. In these sections it is now possible to return to the roads previously improved and by

further expenditure, now possible, advance the improvement to a stage more consistent with the increasing requirements of the traffic. The need for the further improvement is greatest in those sections where the restricted initial improvement least adequately met the needs of traffic; and the type of the stage construction is highest in those sections where traffic has attained the greatest density.

Thus, as shown in Table 2, the mileage of stage construction completed in the New England and East North Central States was quite small, and there was none in the Middle Atlantic States. In the first two sections the entire mileage completed was of high-type bituminous macadam or better. These are sections in which highway improvement has long been in progress; in which the roads constituting the Federal-aid system are well developed; and traffic on the system is relatively heavy.

TABLE 2.—*Mileage of stage construction completed during the fiscal year 1930, by groups of States*

Group of States	Mileage of stage construction completed during year	Percentage of total	Percentage of mileage of bituminous macadam or higher type
New England	1.7	0.1	100.0
Middle Atlantic			
South Atlantic	149.9	7.5	84.9
East North Central	34.6	1.7	100.0
East South Central	54.2	2.7	29.0
West North Central	981.2	48.8	36.5
West South Central	441.5	21.9	98.6
Mountain	317.7	15.8	1.5
Pacific	30.4	1.5	31.5
Total	2,011.2	100.0	49.3

The greatest mileage of stage construction completed was in the West North Central States; and much of it was of a type lower than bituminous macadam. This is a section in which a few years ago the roads were generally unimproved. As a first step it was necessary to limit the expenditure per mile rather narrowly in order to make it cover as much as possible of the large mileage awaiting improvement. Now it becomes possible to return to the roads initially improved by grading and draining only and add surfaces of low and intermediate type which will reasonably meet the needs of traffic for several years more.

In the West South Central States, where, next to the group adjoining them on the north, the mileage of completed stage construction was greatest, a similar process of adjustment is under way, but the type of improvement is generally higher than in the neighboring group. The situation in this section more nearly resembles the condition which prevails in the South Atlantic States.

In the Mountain States traffic is still relatively light, and it is possible to meet the increased requirements with supplementary improvements of low cost. Much of the stage construction in this area consists of the building of low-cost bituminous-mixed surfaces, a type which has proved very effective in this region.

RECONSTRUCTION OF FEDERAL-AID ROADS

This year, for the first time since the beginning of the Federal-aid road work, there is a small amount of reconstruction work to report. By the close of the year reconstruction had been completed on 20.8 miles of road previously improved with Federal aid in 5 States; and at the close of the year there were 18.4 miles in 4 States that were in course of reconstruction and 7.3 miles in 2 States that had been approved for reconstruction.

Reconstruction differs from stage construction in the fact that the latter represents a deliberate postponement of a part of an improvement known to be required to meet the demands of anticipated traffic, whereas the former becomes necessary by reason of the overtaxing of an improvement originally believed to be adequate by an unanticipated traffic.

To projects built under the stage-construction plan the Federal contribution is limited to a total payment of $15,000 a mile (or other maximum payment prescribed by the law.) The supplementary stages of improvement are definitely anticipated and provided for in the original project agreement, and a portion of the permissible maximum allotment of Federal funds is reserved for payment when the deferred improvement is completed.

When, however, a road, which has been previously constructed to a standard regarded at the time as consistent with traffic requirements, is subjected to a traffic for which it is unsuited and by such traffic is worn out in spite of the best efforts of the State to maintain it, reconstruction is required; and the Federal law permits allotment of additional Federal funds to the full amount payable for original construction.

The increase in highway traffic in the last 5 or 10 years has exceeded all reasonable estimates; and types of construction which 10 or even 5 years ago were considered adequate to meet the probable future traffic have in certain instances been found to be unequal to the demands of a traffic exceeding, in number of vehicles and particularly in the weight and speed of the heavier units, the estimates at the time of construction.

In such cases the roads previously aided are eligible for further allotment of aid toward their reconstruction; but no such additional aid is granted unless there is a clear record of the satisfactory maintenance of the original improvement by the State.

The mileage, total cost, and Federal-aid allotments to reconstruction completed during the fiscal year and in progress and approved at the end of the year are reported in Tables 3, 4, and 5. The mileage reported in these tables does not increase the total mileage improved with Federal aid. The total costs and Federal-aid allotments relate to the reconstruction only.

TABLE 3.—*Federal-aid projects on which reconstruction had been completed on June 30, 1930*

State	Total cost	Federal aid	Miles
Louisiana	$304,044.39	$113,160	7.5
Maine	92,751.08	29,175	1.9
Maryland	304,148.92	98,370	6.6
Massachusetts	158,300.30	41,340	2.7
New Hampshire	150,280.99	30,960	2.1
Total	1,009,525.68	313,005	20.8

TABLE 4.—*Federal-aid projects on which reconstruction was in progress on June 30, 1930*

State	Estimated total cost	Federal aid allotted	Miles
Maryland	$309,088.95	$145,550.00	5.9
Massachusetts	130,236.04	39,225.00	2.6
Oklahoma	253,454.06	106,295.29	8.5
Vermont	60,086.66	21,495.00	1.4
Total	752,865.71	312,565.29	18.4

TABLE 5.—*Federal-aid projects which were approved for reconstruction on June 30, 1930*

State	Estimated total cost	Federal aid allotted	Miles
Maine	$78,823.61	$23,190	1.5
Maryland	329,302.82	130,000	5.8
Total	408,126.43	153,190	7.3

The original types of the roads reconstructed, in process of reconstruction, and approved for reconstruction, the age of the roads at the time of reconstruction, and the type of the road after reconstruction are shown in Tables 6, 7, and 8.

TABLE 6.—*Federal-aid projects on which reconstruction had been completed on June 30, 1930, by types of construction*

State	Age	Original type					
		Gravel, untreated		Bituminous macadam		Bituminous concrete	
		New type	Miles	New type	Miles	New type	Miles
	Years						
Louisiana	4	Bituminous concrete.	7.5				
Maine	7			Portland cement concrete.	1.9		
Maryland	8			do	6.6		
Massachusetts	8			do	2.7		
New Hampshire	9					Portland cement concrete.	2.1

TABLE 7.—*Federal-aid projects on which reconstruction was in progress on June 30, 1930, by types of construction*

State	Age	Original type					
		Gravel, untreated		Bituminous concrete		Portland cement concrete	
		New type	Miles	New type	Miles	New type	Miles
	Years						
Maryland	10					Portland cement concrete.	5.9
Massachusetts	11			Bituminous macadam.	2.6		
Oklahoma	8	Portland cement concrete.	8.4				
Do	8	Bridge	.1				
Vermont	4	Portland cement concrete.	1.4				

TABLE 8.—*Federal-aid projects which were approved for reconstruction on June 30, 1930, by types of construction*

State	Age	Original type, bituminous macadam	
		New type	Miles
	Years		
Maine	10	Portland cement concrete	1.5
Maryland	10	do	5.8

CHANGES IN THE FEDERAL-AID HIGHWAY SYSTEM

In accordance with section 3 of the amendatory act of May 21, 1928, the mileage of the Federal-aid system, originally limited to 7 per cent of the certified total mileage of roads in each State, may be increased by an amount equal to the mileage of the designated system in each State lying within the boundaries of national forests, Indian reservations, and other Federal reservations.

The total mileage of the system within such reservations, as determined up to the close of the fiscal year, is 5,456.11 miles, and the addition of this mileage to the original 7 per cent limit raises the permissible mileage of the initial system to 206,018 miles.

By addition to the system during the past year, made possible in part by the provisions of section 3, the mileage of the initial system has been increased to 191,846.16 miles. This mileage has been further increased by extensions of the system in three States in which the initial 7 per cent system has been fully improved to the satisfaction of the Secretary of Agriculture.

The States in which such extensions have been approved are: Delaware, in which the extension is 284.28 miles; Maryland, with an extension of 668.12 miles; and Rhode Island, in which there has been an extension of 251.30. The sum of these extensions, being 1,203.7 miles, added to the initial system thus far designated raises the mileage of the total system to 193,049.86 miles as of June 30, 1930, an increase of 4,192.7 miles in the last year.

The mileage of the system within Federal reservations in each of the States in which such mileage has been reported and approved up to June 30, 1930, is given in Table 9.

TABLE 9.—*Mileage of Federal-aid highway system within Federal reservations, being the amounts by which the 7 per cent limiting mileage may be exceeded in each State or Territory*

State	Mileage within Federal reservations	State	Mileage within Federal reservations	State	Mileage within Federal reservations
Arizona	547.20	Minnesota	74.80	Pennsylvania	79.46
Arkansas	119.70	Mississippi	10.40	South Dakota	474.50
California	457.00	Montana	864.32	Tennessee	77.64
Colorado	363.50	Nebraska	11.25	Utah	68.90
Georgia	57.80	Nevada	25.26	Virginia	30.72
Idaho	468.40	New Hampshire	33.42	Washington	353.21
Illinois	4.50	New Mexico	350.08	West Virginia	29.06
Iowa	2.00	New York	16.47	Wisconsin	45.50
Kansas	14.70	North Carolina	159.34	Wyoming	275.90
Kentucky	6.00	North Dakota	23.39	Hawaii	4.34
Maine	4.50	Oklahoma	16.25		
Michigan	26.50	Oregon	360.10	Total	5,456.11

The mileage of the designated Federal-aid system in each State, including the authorized extensions in three States, and the mileage within Federal reservations, is given in Table 24, which also shows the distribution, by States, of the 84,012.8 miles improved up to June 30, 1930.

The mileage reported as improved with Federal aid still includes a small amount improved prior to 1921 and not incorporated in the designated system. The amount of such extra-system mileage is being gradually reduced by the substitution of mileage within the system and the transfer of the Federal aid paid for the improvement of the original roads to the improvement of the substituted mileage.

The effect of this procedure is to return to the Federal Government the amount of its investment in the roads outside the Federal-aid system, so that these roads are no longer considered Federal-aid roads. The States are thus released of their obligation to the Government to maintain them and may, if they so desire, return them to the control of the county or other local authorities.

A year ago it was reported that the Federal aid originally paid for the improvement of 485.3 miles of such roads outside of the system had been transferred to other roads within the system. In the past year the continuation of this procedure has returned to the Government the amount originally expended on other roads outside the system totalling 210.7 miles, and this money has been allotted to the initial or stage construction of other roads within the system.

The distribution, by States, of the mileage replaced during the fiscal year, the total cost of its improvement, and the Federal aid allotted to it and now returned are shown in Table 10. The type classification of the newly replaced mileage is shown in Table 11. As will be noted, it is predominantly of low type, 180 of the 210.7 miles, or 85 per cent, having been improved with types of surface less durable than bituminous macadam.

TABLE 10.—*Total cost, Federal aid, and mileage of roads replaced during the fiscal year ended June 30, 1930, for which other improvements have been substituted*

State	Total cost	Federal aid	Mileage	State	Total cost	Federal aid	Mileage
Arkansas	$633,681.83	$291,548.32	63.9	Pennsylvania	$127,359.57	$46,600.00	2.3
Colorado	68,298.37	38,055.90	.3	South Dakota	75,419.25	37,709.62	15.0
Connecticut	8,873.18	2,800.00	.1	Vermont	15,225.77	6,507.28	.3
Kansas	122,789.84	44,029.43	2.1	Virginia	405,760.05	197,912.13	16.8
Massachusetts	70,475.58	30,160.87	.5	West Virginia	40,487.55	18,555.41	2.2
Minnesota	321,656.35	138,763.95	28.4	Wisconsin	1,126,503.55	417,790.21	78.3
Mississippi	2,991.26	1,495.63	.3				
Oklahoma	107,419.34	53,709.67	.2	Total	3,126,941.49	1,325,638.42	210.7

TABLE 11.—*Mileage of roads replaced during the fiscal year ended June 30, 1930, for which other improvements have been substituted, by types of construction, by States*

State	Graded and drained	Gravel, untreated	Macadam, untreated	Macadam, treated	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
Arkansas		31.5		32.3					0.1	63.9
Colorado									.3	.3
Connecticut			0.1							.1
Kansas	0.4						1.0	0.7		2.1
Massachusetts					0.4				.1	.5
Minnesota	1.4	27.0								28.4
Mississippi		.3								.3
Oklahoma									.2	.2
Pennsylvania						2.3				2.3
South Dakota		15.0								15.0
Vermont			.3							.3
Virginia	.3		11.2		5.2				.1	16.8
West Virginia					2.2					2.2
Wisconsin	19.4	40.8					18.1			78.3
Total	21.5	114.6	11.6	32.3	7.8	2.3	19.1	.7	.8	210.7

The replacements of the last year bring the total of mileage thus far replaced to 696 miles. The location of this mileage, its total cost, and the Federal aid originally allotted to it are shown in Table 12, and its type classification in Table 13. Of the total mileage more than 90 per cent was improved with types of surface less durable than bituminous macadam, a fact which is indicative of the relatively slight importance of these roads.

TABLE 12.—*Total cost, Federal aid, and mileage of roads replaced to June 30, 1930, for which other improvements have been substituted*

State	Total cost	Federal aid	Mileage	State	Total cost	Federal aid	Mileage
Alabama	$33,947.60	$16,433.17	5.5	New York	$43,692.89	$18,245.34	1.1
Arkansas	1,003,545.20	455,193.72	99.1	North Dakota	42,372.46	20,968.87	7.1
Colorado	68,298.37	38,055.90	.3	Oklahoma	107,419.34	53,709.67	.2
Connecticut	8,873.18	2,800.00	.1	Pennsylvania	127,359.57	46,600.00	2.3
Kansas	125,874.60	45,571.81	3.6	South Carolina	4,779.96	2,294.32	
Louisiana	31,433.22	14,301.06	1.1	South Dakota	75,419.25	37,709.62	15.0
Massachusetts	82,625.68	36,235.92	.6	Texas	99,290.75	33,333.34	7.4
Michigan	357,020.74	163,618.76	20.9	Vermont	15,225.77	6,507.28	.3
Minnesota	1,641,050.96	630,046.33	206.8	Virginia	642,118.35	297,110.16	25.7
Mississippi	2,991.26	1,495.63	.3	West Virginia	40,487.55	18,555.41	2.2
Montana	783.93	391.96	.2	Wisconsin	3,231,426.13	1,256,707.13	275.7
Nebraska	293.68	146.84	.2	Wyoming	11,908.56	5,160.81	10.4
Nevada	10,046.35	5,023.17					
New Mexico	52,715.38	25,964.81	9.9	Total	7,861,000.73	3,232,181.03	696.0

TABLE 13.—*Mileage of roads replaced to June 30, 1930, for which other improvements have been substituted, by types of construction, by States*

State	Graded and drained	Sand-clay, untreated	Gravel, untreated	Macadam, untreated	Macadam, treated	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
Alabama			5.5								5.5
Arkansas			63.5		35.3			0.1		0.2	99.1
Colorado										.3	.3
Connecticut				0.1							.1
Kansas	1.9							1.0	0.7		3.6
Louisiana			1.1								1.1
Massachusetts						0.4				.2	.6
Michigan			14.4		2.6		3.9				20.9
Minnesota	18.6		182.7					5.5			206.8
Mississippi			.3								.3
Montana	.1		.1								.2
Nebraska	.2										.2
New Mexico			9.9								9.9
New York								1.1			1.1
North Dakota	6.8									.3	7.1
Oklahoma										.2	.2
Pennsylvania							2.3				2.3
South Dakota			15.0								15.0
Texas			7.4								7.4
Vermont				.3							.3
Virginia	.3			12.6		12.7				.1	25.7
West Virginia						2.2					2.2
Wisconsin	68.9	19.8	150.1					36.8		.1	275.7
Wyoming	10.4										10.4
Total	107.2	19.8	450.0	13.0	37.9	15.3	6.2	44.5	.7	1.4	696.0

The Federal aid originally paid for the improvement of the 696 miles replaced has been allotted with additional funds to 583.2 miles of initial construction and 72.2 miles of stage construction in the same States. Of these mileages, 427.2 miles of initial construction and 66.2 miles of stage construction had been completed by the close of the fiscal year. The estimated total cost of this work, the Federal aid substituted, additional Federal aid allotted, and the mileage involved are shown in Table 14; and similar information relative to the 156 miles of initial construction and 6 miles of stage construction still in progress at the close of the fiscal year is given in Table 15.

TABLE 14.—*Total cost, Federal aid substituted, additional Federal aid allotted, and initial and stage mileage of substituted improvements completed to June 30, 1930*

State	Estimated total cost	Federal aid substituted	Additional Federal aid allotted	Mileage	
				Initial	Stage
Alabama	$199,154.95	$16,433.17	$70,244.83	16.7	
Arkansas	2,239,167.08	357,902.56	745,084.32	67.2	3.8
Kansas	159,960.10	24,585.53	35,970.03	13.2	
Louisiana	204,578.15	5,000.00	97,289.07	2.9	
Massachusetts	245,104.53	6,075.05	69,410.72	4.8	
Michigan	612,511.33	69,386.96	138,071.04	14.5	
Minnesota	2,230,265.11	569,210.59	74,082.43	58.1	6.6
Montana	26,261.68	92.64	11,179.68	2.0	
Nebraska	5,557.42	146.84	2,631.87	.9	
Nevada	38,952.47	5,023.17	29,009.88	6.3	
New Mexico	141,891.17	25,840.55	64,486.07	7.3	
New York	333,869.60	18,245.34	125,355.00	9.5	
North Dakota	178,100.11	20,968.87	54,308.01	33.0	
Oklahoma	207,575.96	53,709.67	42,255.33	2.9	6.7
South Carolina	237,929.62	2,294.32	82,418.67		7.6
Texas	451,779.61	33,333.34	179,177.28		18.1
Virginia	1,344,172.23	297,110.16	60,503.33	37.6	
West Virginia	328,332.97	18,555.41	52,538.17	6.3	
Wisconsin	4,389,202.68	1,099,885.55	956,022.44	144.0	13.6
Wyoming	18,158.59	5,160.81			9.8
Total	13,592,525.36	2,628,960.53	2,890,038.17	427.2	66.2

TABLE 15.—*Total cost, Federal aid substituted, additional Federal aid allotted, and initial and stage mileage of substituted improvements under construction on June 30, 1930*

State	Estimated total cost	Federal aid substituted	Additional Federal aid allotted	Mileage	
				Initial	Stage
Arkansas	$532,607.81	$97,291.16	$160,939.91	17.1	
Colorado	514,593.09	38,055.90	222,056.55	10.2	
Connecticut	180,495.42	2,800.00	87,447.71	.5	
Kansas	336,221.44	20,986.28	134,656.48	8.0	
Louisiana	1,145,393.93	9,301.06	563,395.90	.7	
Massachusetts	911,886.68	30,160.87	226,385.86	12.5	
Michigan	514,366.38	94,231.80	132,001.20	12.9	
Minnesota	884,895.98	60,835.74	145,842.84	12.1	6.0
Mississippi	171,041.09	1,495.63	84,024.91	1.5	
Montana	201,469.62	299.32	106,953.18	16.6	
New Mexico	106,217.79	124.26	67,249.68	.5	
Pennsylvania	334,117.63	46,600.00	42,620.00	6.0	
South Dakota	86,386.15	37,709.62	9,802.75	15.8	
Vermont	666,826.02	6,507.28	135,010.07	13.2	
Wisconsin	727,390.59	156,821.58	178,567.96	28.4	
Total	7,313,909.62	603,220.50	2,296,955.00	156.0	6.0

The type classification of the substituted initial and stage construction completed and in progress at the close of the fiscal year is shown in Tables 16, 17, and 18. Consistent with the greater importance of the roads involved, these improvements are of considerably higher type than those replaced.

TABLE 16.—*Mileage of completed initial improvements substituted for replaced roads to June 30, 1930, by types of construction, by States*

State	Graded and drained	Sand-clay, untreated	Gravel		Macadam, treated	Low-cost bituminous mixture	Bituminous macadam	Portland cement concrete	Bridges and approaches	Total
			Untreated	Treated						
Alabama	16.6								0.1	16.7
Arkansas	10.1		8.2					48.0	.9	67.2
Kansas	11.1							.7	1.4	13.2
Louisiana									2.9	2.9
Massachusetts							4.8			4.8
Michigan			3.1					11.4		14.5
Minnesota	7.6			17.6				32.8	.1	58.1
Montana			1.8					.2		2.0
Nebraska		0.9								.9
Nevada						6.3				6.3
New Mexico			4.0			2.9		.4		7.3
New York							.2	9.3		9.5
North Dakota	20.0			12.9					.1	33.0
Oklahoma								2.9		2.9
Virginia	7.3				3.6		20.6	5.8	.3	37.6
West Virginia							6.3			6.3
Wisconsin			26.5	4.0				112.9	.6	144.0
Total	72.7	.9	43.6	34.5	3.6	9.2	31.9	224.4	6.4	427.2

TABLE 17.—*Mileage of completed stage improvements substituted for replaced roads to June 30, 1930, by types of construction, by States*

State	Graded and drained	Low-cost bituminous mixture	Portland cement concrete	Total
Arkansas			3.8	3.8
Minnesota	6.6			6.6
Oklahoma			6.7	6.7
South Carolina			7.6	7.6
Texas			18.1	18.1
Wisconsin			13.6	13.6
Wyoming		9.8		9.8
Total	6.6	9.8	49.8	66.2

TABLE 18.—*Mileage of initial improvment under construction on June 30, 1930, substituted for replaced roads, by types of construction, by States*

State	Graded and drained	Gravel, untreated	Bituminous macadam	Portland cement concrete	Bridges and approaches	Total
Arkansas				17.0	0.1	17.1
Colorado				9.5	.7	10.2
Connecticut				.4	.1	.5
Kansas	6.7			1.0	.3	8.0
Louisiana					.7	.7
Massachusetts			7.3	5.1	.1	12.5
Michigan				12.8	.1	12.9
Minnesota		12.0			.1	12.1
Mississippi	1.3				.2	1.5
Montana		16.6				16.6
New Mexico					.5	.5
Pennsylvania				6.0		6.0
South Dakota		15.8				15.8
Vermont				13.4		13.4
Wisconsin		12.7		15.4	.1	28.2
Total	8.0	57.1	7.3	80.6	3.0	156.0

NOTE.—The only mileage of stage improvement under construction on June 30, 1930, substituted for abandoned roads is 6 miles of Portland cement concrete in Minnesota.

As the substituted stage improvements are applied to roads already improved to a certain degree with Federal aid, the net effect of all the above-described substitutions upon the mileage considered as improved with Federal aid is to reduce the mileage at present improved or under improvement by the difference between 696 and 583.2, or 112.8 miles. A comparison of the replaced and substituted initially improved mileages, by States, is given in Table 19.

TABLE 19.—*Comparison of the replaced and substituted initially improved mileages on June 30, 1930, by States*

State	Replaced mileage	Substituted mileage	Changes in the mileage of roads improved with Federal aid	
			Increase (miles)	Decrease (miles)
Alabama	5.5	16.7	11.2	
Arkansas	99.1	84.3		14.8
Colorado	.3	10.2	9.9	
Connecticut	.1	.5	.4	
Kansas	3.6	21.2	17.6	
Louisiana	1.1	3.6	2.5	
Massachusetts	.6	17.3	16.7	
Michigan	20.9	27.4	6.5	
Minnesota	206.8	70.2		136.6
Mississippi	.3	1.5	1.2	
Montana	.2	18.6	18.4	
Nebraska	.2	.9	.7	
Nevada	(1)	6.3	6.3	
New Mexico	9.9	7.8		2.1
New York	1.1	9.5	8.4	
North Dakota	7.1	33.0	25.9	
Oklahoma	.2	2.9	2.7	
Pennsylvania	2.3	6.0	3.7	
South Carolina	(1)	(2)		
South Dakota	15.0	15.8	.8	
Texas	7.4	(2)		7.4
Vermont	.3	13.4	13.1	
Virginia	25.7	37.6	11.9	
West Virginia	2.2	6.3	4.1	
Wisconsin	275.7	172.2		103.5
Wyoming	10.4	(2)		10.4
Total	696.0	583.2	162.0	274.8

[1] Less than 0.1 mile.

[2] Stage improvement substituted.

TYPES OF FEDERAL-AID ROADS

The 7,317.4 miles initially improved during the year consists of 2,556.2 miles of graded and drained earth roads; 227.1 miles of untreated sand-clay roads; 1,382.5 miles of untreated gravel roads; 66.3 miles of bituminous-treated gravel roads; 36.2 miles of water-bound macadam roads; 14.1 miles of surface-treated macadam roads; 160.4 miles of low-cost bituminous mixed surfaces; 318.5 miles of bituminous macadam roads; 135.2 miles of bituminous concrete pavement; 2,340.3 miles of Portland cement concrete pavement; and 40 miles of block pavement. The remaining 40.6 miles is made up of numerous bridges and their approaches, each structure more than 20 feet in length.

Of these roads initially improved, 39 per cent of the mileage is improved with bituminous macadam or one of the higher types of pavement; 3 per cent with intermediate bituminous-treated types of surface; and 58 per cent with untreated macadam and lower types of surface, including a considerable mileage that is only graded and drained.

The choice of surface type, in all cases representing the concurrence of the bureau and the respective State highway departments, is made after consideration of the traffic requirements, the availability of funds, the general level of road improvement in the area, and other pertinent factors. In general, the types built are in close accord with the demands of traffic, and the more resistant and hence more expensive improvements are found to the greater extent in those sections of the country where traffic is heaviest. This fact is indicated by Table 20, in which the number of registered motor vehicles per mile of the Federal-aid system in each geographic area is used as an approximate index of the general density of traffic in the area.

TABLE 20.—*Relation of the types of initial improvements completed during the fiscal year 1930 and the general density of motor-vehicle traffic on the Federal-aid highway system, by groups of States*

Group of States	Number of motor vehicles per mile of Federal-aid system [1]	Percentage of mileage of initial improvements completed		
		Bituminous macadam and higher types	Intermediate bituminous-treated types	Untreated macadam and lower types
Middle Atlantic	395	90		10
New England	268	87	10	3
Pacific	240	25	20	55
East North Central	230	84		16
South Atlantic	107	61	3	36
West South Central	97	28		72
East South Central	83	23		77
West North Central	75	15	3	82
Mountain	40	3	6	91
Total	137	39	3	58

[1] As registered in the several States during the calendar year 1929.

The effect of stage construction and the substitution of higher types of improvement for replaced early improvements outside of the Federal-aid system is shown by the fact that whereas the pavement types and bituminous macadam constituted only 39 per cent of the total of mileage initially improved, the net increase in the mileage of these types was 61 per cent of the total net increase in mileage, exclusive of bridges, during the year. The intermediate bituminous-treated types of surface which formed only 3 per cent of the year's initial improvements constituted 9 per cent of the net increase in mileage; and the untreated macadam and lower types including graded and drained earth roads, which made up 58 per cent of the initially improved mileage were only 30 per cent of the net increase in mileage. Graded and drained earth roads, which constituted 35 per cent of the initially improved mileage formed only 17 per cent of the net increase in mileage.

As shown by Table 21, the percentage increases in the mileage of low-cost bituminous-mixed surfaces and bituminous-treated gravel surfaces were greater than the increases of any other type. The large percentages in the case of these types, however, are the result of the relatively small mileages involved. Of the types of which there are large mileages, Portland cement concrete shows the largest perecentage increase. The same table also shows that the increase of the four higher types of improvement was 13 per cent, as compared with 4.7 per cent for the lower types, and a general increase of 7.8 per cent.

TABLE 21.—*Mileage of the several types of Federal-aid roads improved at the close of the fiscal years 1929 and 1930, and percentage of change*

Type	Mileage at close of fiscal year 1929	Mileage at close of fiscal year 1930	Percentage change during fiscal year 1930
Graded and drained	11,407.8	12,448.5	9.1
Sand-clay:			
Untreated	7,049.0	7,166.2	1.7
Treated	16.5	16.5	
Gravel:			
Untreated	27,946.9	28,607.9	2.4
Treated	364.6	482.5	32.3
Macadam:			
Untreated	1,747.1	1,754.1	.4
Treated	639.6	603.4	−5.7
Low-cost bituminous mix	294.3	742.0	152.1
Bituminous macadam	3,671.9	4,057.1	10.5
Bituminous concrete	3,039.1	3,204.7	5.4
Portland cement concrete	20,612.0	23,693.3	14.9
Block	866.6	904.7	4.4
Total	77,655.4	83,680.9	7.8

Of the 84,012.8 miles classified as improved with Federal aid at the close of the year, 12,448.5 miles are graded and drained earth roads; 7,166.2 miles are untreated sand-clay roads; 16.5 miles are bituminous-treated sand-clay roads; 28,607.9 miles have untreated gravel surfaces and 482.5 miles bituminous-treated surfaces of the same type; 1,754.1 miles have water-bound macadam surfaces; 603.4 miles are surfaced with bituminous-treated macadam; 742 miles are improved with low-cost bituminous-mixed surfaces; 4,057.1 miles are

surfaced with bituminous macadam; 3,204.7 miles are paved with bituminous concrete; 23,693.3 miles are Portland cement concrete pavements; and 904.7 miles are block pavements. The remaining 331.9 miles consists of bridges, each more than 20 feet in span, and their approaches.

BRIDGE CONSTRUCTION

The bridges completed as initial improvements during the year, with their approaches, have an aggregate length of 40.6 miles. Those added by stage construction aggregate 5.3 miles, making a total of 45.9 miles of bridges and their approaches completed during the fiscal year. This may be compared with the corresponding figure of 47.1 miles completed during the fiscal year 1929. The bridges under construction and approved for construction at the end of the year, as both initial and stage construction, have, with their approaches, a total length of 85.7 miles.

Including the structures just completed, the Federal-aid bridges now in use have a total length, with their approaches, of 331.9 miles.

A list of the bridges completed during the year which cost $75,000 or more is given in Table 22. These, the longest and most expensive of the projects completed, vary in length from about one-tenth of a mile to nearly 2 miles and have an aggregate length, with their approaches, of 10.4 miles. The rest of the mileage completed is made up of numerous smaller and less expensive bridges, all more than 20 feet in span.

TABLE 22.—*Federal-aid bridges completed during the fiscal year 1930 at a cost of $75,000 or more each*

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
			Dollars	*Miles*
Arkansas	Marianna-Memphis Highway	St. Francis River	251,700	0.3
Do	Princeton-Camden Road	Fourbridges, Ouachita River	270,200	.9
Arkansas-Tennessee	Memphis, Tenn., and Chatfield, Ark.	Mississippi River	1,237,300	1.8
California	The Coast Road	Overhead crossing, Southern Pacific Railroad.	77,500	.1
Do	Elk Valley Road	Smith River	160,400	.1
Do	Valley Road between Bakersfield and San Fernando.	Santa Clara River	201,300	.4
Connecticut	Between Hartford and Putnam.	Willimantic River	76,100	.1
Delaware	Newport Highway	Christiana River	144,500	.1
Florida	State Road No. 2	Dead River	84,000	.1
Indiana	The Dixie Bee Line Highway	White River	253,300	.4
Kansas	Wamego-Eskridge Highway	Kansas River	132,100	.2
Louisiana	Tullos-Rochelle Highway	Little River	118,500	.1
Massachusetts	Northampton Highway	Manhan River	119,900	.2
Michigan	Ann Arbor-Battle Creek Road	Overpass, Michigan Electric Railway & Michigan Central Railroad.	102,200	.2
Do	The River Road	Saginaw River	91,500	----------
Do	Monroe-Detroit Road in Wayne County.	Underpass, Wabash Railway yard.	582,000	.3
Do	Bedford-Pontiac Road	Underpass, Grand Trunk Railroad.	95,100	.2
Minnesota-North Dakota	East Grand Forks, Minn.-Grand Forks, N. Dak.	Red River of the North	325,200	.2
Mississippi	The Delta Road in Warren County	Yazoo River (two bridges)	365,200	.3
New York	Bradford-Carrollton	Overpass, Erie Railroad	184,000	.5
North Dakota	State Route No. 5	Des Lac Lake Crossing	118,000	.3

TABLE 22.—*Federal-aid bridges completed during the fiscal year 1930 at a cost of $75,000 or more each*—Continued

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
			Dollars	*Miles*
Ohio	Ohio River Road, Belmont County.	Overpass, Pennsylvania Railroad Co., Wheeling & Lake Erie Railroad Co., and Wheeling Traction Co.	85,600	0.1
Do	Cleveland - East Liverpool Highway.	Overpass, Pennsylvania Railroad Co., Wheeling & Lake Erie Railroad Co., and Northern Ohio Traction & Light Co.	500,000	.3
Do	At Vermilion	Vermilion River	114,500	.2
Do	U. S. Route No. 11 at Austintown.	Meander Creek	80,800	
Oregon	At Maupin	Deschutes River	108,400	.3
Do	Between Reedsport and Drain	Umpqua River	124,700	.3
Pennsylvania	Lock Haven-North Bend Road.	Susquehanna River	303,400	.2
South Carolina	Between Newberry and Columbia.	Broad River and Columbia Canal.	283,200	.2
Tennessee	Knoxville-Asheville Road	French Broad River	117,700	.3
Do	Memphis - Bristol Highway near Brownsville.	Hatchie River	250,900	.6
Texas	The Brenham - Hempstead Road.	Brazos River	341,600	.2
Do	Highway No. 12, Victoria County.	Coleto Creek	75,300	.1
Virginia	State Route No. 36 in Clarke County.	Shenandoah River	121,600	.2
Do	Alexandria - Fredericksburg Road.	Occoquan Creek	83,800	.2
Washington	Pacific Highway, between Kelso and Vancouver.	Kalama River	79,600	.1
Do	Between Colville and Laurier	Columbia River	267,700	.2
Wisconsin	Atwater crossing near Shorewood.	Underpass, Chicago & Northwestern Railroad.	155,500	.1

PROVISION FOR CONSTRUCTION OF CERTAIN ROADS AT THE SOLE EXPENSE OF THE FEDERAL GOVERNMENT

On June 24, 1930, an act was approved which authorizes the Secretary of Agriculture to cooperate with the State highway departments and the Department of the Interior in the survey, construction, reconstruction, and maintenance of main roads through unappropriated or unreserved public lands, nontaxable Indian lands, or other Federal reservations other than forest reservations. No contribution from the States will be required toward the improvement of roads built under the provisions of this act over lands of the character described.

The act provides that the appropriations which the Congress may authorize under its provisions shall be apportioned among those States having more than 5 per cent of their area in lands of the several kinds described, and shall be prorated to such States in the proportion that such lands in each State bear to the total area of land of like character in all the eligible States.

The act provides further that in the allocation of funds authorized preference shall be given to those projects which are located in the Federal-aid highway system as now or hereafter designated.

No appropriation has yet been authorized and no construction can be undertaken until funds are provided. Meanwhile consideration is being given to the procedure that will be required to give effect to the provisions of the act.

As the department is authorized to cooperate only with State highway departments and the Department of the Interior it appears that the application of the act is limited to those main roads included in the Federal-aid highway system as now designated and those now under the jurisdiction of the State highway departments or which may be taken into the State systems.

The survey of traffic on the Federal-aid system in the Western States, now nearing completion, will supply data with reference to the general average of traffic on the main roads of these States which may be taken as a standard with which to measure the eligibility of other roads not included in the survey. As specifically provided by the act, preference will be given to those roads, qualifying as main roads in view of the density of the traffic they serve, which are now included in the Federal-aid system or which will serve as desirable extensions of that system as at present designated.

Reasonable application of the act would seem to be confined to roads of the Federal-aid and State highway systems; to those that the States have authority to take over as parts of the State systems or will obtain authority to take over as enlargements of the main road system; to roads in Indian or other reservations under the Department of the Interior, which the Secretary of the Interior, the Secretary of Agriculture, and the respective State highway departments consider as desirable additions to the main roads system; and to a possible limited mileage of roads in Federal reservations, other than national forests, and not under the control of the Department of the Interior.

As in many places the unappropriated and unreserved public lands are not continuous over a large area, it is anticipated that roads qualifying as "main roads" and selected for improvement under this act may pass alternately through public and private land. In such cases it seems clear that the authority granted to the Federal Government to pay the entire cost of improvement extends only to those parts of such roads that actually lie within publicly owned land.

FEDERAL FUNDS APPORTIONED AND OBLIGATED

The appropriation authorized for the fiscal year 1930 was $75,000,000, the same amount that has been authorized for each year since 1925. This sum, less 2½ per cent deducted for Federal administration and highway research, was apportioned among the several States and the Territory of Hawaii on December 29, 1928; and the amount credited to each State is shown in Table 36.

As contemplated by the provision of the law which requires the apportionment of the funds authorized for each fiscal year at least six months before the beginning of the fiscal year, a portion of the 1930 funds was obligated before the beginning of the year, and there remained at that time an unobligated balance of only $56,339,874.64.

The original authorization for the fiscal year 1931 was also $75,000,000, and the $73,125,000 of this sum remaining after deduction of the administrative percentage was apportioned on December 2,

1929. This entire amount was available for allotment to new projects immediately upon its apportionment; but if there had been no further authorization, only so much of it as would provide for an uninterrupted program at the rate set by the $75,000,000 appropriations, would have been allotted during the remainder of the fiscal year, and the year would have ended with an unobligated balance approximately equal to that which remained at the end of the preceding year. This would have entailed the allotment of about $17,000,000 during the months from January to June, inclusive, leaving the balance of approximately $56,000,000 to be obligated to new projects between July 1, 1930, and the date of the next apportionment, which normally would have been in December, 1930.

That this does not approximately express the result of the year's activity is due to the fact that Congress, in the act approved April 4, 1930, authorized an additional appropriation of $50,000,000 for the fiscal year 1931, raising the total authorized for that year to $125,000,000; and this additional sum, immediately apportioned, was also available for allotment to projects immediately. By this act, which also authorized appropriations of $125,000,000 for the fiscal years 1932 and 1933, Congress provided for a program at the higher rate, and the States proceeded immediately to adjust their plans to the increased rate. Although only three months of the fiscal year remained, the results show that this adjustment was very promptly begun, for instead of obligating approximately $73,000,000, as would otherwise have been the case, the amount obligated during the fiscal year reached $102,498,083.84, which was more than $32,000,000 greater than the obligations during the preceding fiscal year and the greatest amount thus far obligated in any year.

It was pointed out in the last annual report that the unobligated balance of funds authorized for previous years had been absorbed and that, for the first time since 1923, the funds obligated during the fiscal year 1929 were within the sum apportioned for the year. It was stated that, although the expenditure of $82,097,380.38 was considerably in excess of the rate of authorization, and although this condition might be expected to exist for a year or two longer, since there is a normal interval of from one to two years between obligation and expenditure of the money, the point had by that time definitely been reached at which, unless there were immediate increase in the appropriations authorized the rate of construction of Federal-aid roads maintained for several years past would be curtailed.

During the fiscal year 1930 the expenditure of $75,880,862.84, although more than $6,000,000 less than the previous year's expenditure, was still slightly greater than the funds apportioned for the year. It may be expected that the large increase in funds obligated, as shown by Table 23, will result in a considerable increase in the expenditure next year; but the annual expenditures will not reach the rate fixed by the new authorizations of $125,000,000 for at least two years and perhaps longer.

TABLE 23.—*Federal-aid funds apportioned to the States and obligated by them for the fiscal years 1923 to 1930, inclusive*

Fiscal year	Apportioned amount of appropriation authorized for the year	Amount of Federal-aid funds obligated during the year	Fiscal year	Apportioned amount of appropriation authorized for the year	Amount of Federal-aid funds obligated during the year
1923	$48,750,000	$77,461,559	1929	$73,125,000	$70,428,896
1924	63,375,000	89,866,864	1930	73,125,000	[1] 102,498,084
1925	73,125,000	87,294,396			
1926	73,125,000	79,608,897	Total	550,875,000	673,533,927
1927	73,125,000	77,453,046	Average	68,859,375	84,191,741
1928	73,125,000	88,922,185			

[1] The sharp increase represented by this amount is due to the obligation of a considerable portion of the enlarged apportionment for the fiscal year 1931.

Although the balance of all apportionments, including that for the fiscal year 1931, unobligated at the close of the fiscal year 1930 was only $75,716,790.80, from which it would appear that the entire apportionment for 1930 and previous years had been absorbed and $46,158,209.20 of the apportionment of $121,875,000 for 1931 in addition, this does not represent the true situation. As a matter of fact, 1 State—Vermont—had already obligated the entire amount of its apportionment of the 1931 authorization; 2 others—Iowa and Maryland—had unobligated balances of the most recent apportionment that could be absorbed on a mile of road; and 37 other States, making a total of 40, had begun to obligate their 1931 apportionments and had drawn more or less deeply on these credits. Of the remaining 8 States, 7—Alabama, Arizona, Florida, Maine, Massachusetts, Montana, and New York—still had not obligated the entire amount of their 1930 apportionments, and 1—Mississippi—had a small balance of its 1929 apportionment and the entire apportionment for 1930 still unobligated.

The Territory of Hawaii, which receives the minimum apportionment of 0.5 per cent of the amount available annually for apportionment, had failed by June 30, 1930, to expend $326,864.96 of the amount apportioned to it for the fiscal year 1928. As the law provides that the amounts apportioned for each fiscal year must be expended by the end of the second succeeding fiscal year, and that balances not expended with the prescribed period must be reapportioned among all the States, Hawaii loses the above amount, which will be immediately reapportioned among all the States and the Territory in accordance with the rule established for original apportionment.

COST OF THE ROADS

The total cost of the 7,317.4 miles of initial construction and the 2,011.2 miles of stage construction completed during the year was $193,648,148.64, of which the Federal Government paid $82,158,756.79, or 42 per cent, and the States the balance. These expenditures were made over the period required to construct the roads, between one and two years. During the same period there were additional expenditures for other projects under construction and not yet completed.

The Federal funds disbursed during the year on all projects active during the period amounted to $75,880,862.84, as shown in Table 36. This was $6,216,517 less than the expenditures of the previous year, but still slightly above the rate set by the annual appropriation of $75,000,000.

The largest disbursements during the year were made to California, Missouri, New York, Pennsylvania, Texas, and Wisconsin. To each of these States the Federal Government paid more than $3,000,000. All other States received less than that amount.

SUMMARY OF FEDERAL-AID ROAD WORK, BY STATES

The progress made in each of the States during the year and the results of the 14 years of Federal-aid road construction are reported in the following condensed summary for each State.

ALABAMA

The Federal-aid highway system includes 3,884 miles, of which 2,153.8 miles have been improved with Federal aid. Of the improved mileage, 194.2 miles were added during the year. At the close of the year 105.4 miles were under construction.

The mileage improved with Federal aid consists of 259.7 miles of graded and drained earth roads, 523.2 miles of untreated sand-clay, 940.1 miles of untreated gravel, 4.4 miles of treated gravel, 20.8 miles of treated macadam, 62.8 miles of bituminous macadam, 104.3 miles of bituminous concrete, and 228.6 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 9.9 miles.

The total cost of all Federal-aid roads completed during the year, including 14.5 miles of stage construction, was $3,073,848.12, of which the Federal share was $1,443,082.40. The disbursement of Federal funds to the State was $1,092,685.93. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $4,083,610.18.

ARIZONA

The Federal-aid highway system includes 1,979 miles, of which 810.3 miles have been improved with Federal aid. Of the improved mileage, 43.1 miles were added during the year. At the close of the year 285.6 miles were under construction.

The mileage improved with Federal aid consists of 80.2 miles of graded and drained earth roads, 58.8 miles of untreated sand-clay, 462 miles of untreated gravel, 55.8 miles of low-cost bituminous-mixed surface, 38.1 miles of bituminous concrete, and 109.3 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 6.1 miles.

The total cost of all Federal-aid roads completed during the year including 46.6 miles of stage construction, was $1,535,443.88, of which the Federal share was $1,379,714.19. The disbursement of Federal funds to the State was $1,560,058.27. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,898,927.83.

ARKANSAS

The Federal-aid highway system includes 5,019 miles, of which 1,741.4 miles have been improved with Federal aid. Of the improved mileage 102.6 miles were added during the year. At the close of the year, 189.1 miles were under construction and 86.4 miles had been approved.

The mileage improved with Federal aid consists of 86.3 miles of graded and drained earth roads, 1,029.4 miles of untreated gravel, 6.4 miles of treated gravel, 41.5 miles of untreated macadam, 110.6 miles of treated macadam, 257.9 miles of bituminous concrete, and 197.4 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 11.9 miles.

The total cost of all Federal-aid roads completed during the year, including 14.3 miles of stage construction, was $3,401,174.82, of which the Federal share was $1,685,445.48. The disbursement of Federal funds to the State was $650,764.79. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,518,012.42.

CALIFORNIA

The Federal-aid highway system includes 4,889 miles, of which 1,880.2 miles have been improved with Federal aid. Of the improved mileage, 335.6 miles were added during the year. At the close of the year, 147.2 miles were under construction and 36.1 miles had been approved.

The mileage improved with Federal aid consists of 382.5 miles of graded and drained earth roads, 468.7 miles of untreated gravel, 22.5 miles of untreated macadam, 133.6 miles of low-cost bituminous-mixed surface, 96.8 miles of bituminous macadam, 174.7 miles of bituminous concrete, and 590.8 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 10.6 miles.

The total cost of all Federal-aid roads completed during the year, including 20 miles of stage construction, was $11,396,353.24, of which the Federal share was $5,087,674.79. The disbursement of Federal funds to the State was $3,931,822.91. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,743,512.14.

COLORADO

The Federal-aid highway system includes 3,332 miles, of which 1,208.1 miles have been improved with Federal aid. Of the improved mileage, 72.3 miles were added during the year. At the close of the year 221.9 miles were under construction, and 29 miles had been approved.

The mileage improved with Federal aid consists of 200.5 miles of graded and drained earth roads, 67.1 miles of untreated sand-clay, 458.7 miles of untreated gravel, 101.2 miles of untreated macadam, 47.7 miles of low-cost bituminous-mixed surface, 13.1 miles of bituminous concrete, and 306.1 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 13.7 miles.

The total cost of all Federal-aid roads completed during the year, including 38.1 miles of stage construction, was $1,883,264.93, of which the Federal share was $994,769.96. The disbursement of Federal funds to the State was $1,402,520.46. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,283,553.54.

CONNECTICUT

The Federal-aid highway system includes 836 miles, of which 243.3 miles have been improved with Federal aid. Of the improved mileage, 14.1 miles were added during the year. At the close of the year 10.9 miles were under construction, and 7.9 miles had been approved.

The mileage improved with Federal aid consists of 0.2 mile of untreated gravel, 17.2 miles of untreated macadam, 39.7 miles of bituminous macadam, 0.6 mile of bituminous concrete, and 181.6 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 4 miles.

The total cost of all Federal-aid roads completed during the year was $770,370.16, of which the Federal share was $255,295.83. The disbursement of Federal funds to the State was $281,922.76. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $714,247.71.

DELAWARE

The Federal-aid highway system includes 550 miles, of which 251 miles have been improved with Federal aid. Of the improved mileage, 45.2 miles were added during the year. At the close of the year 24.9 miles were under construction and 41.2 miles had been approved.

The mileage improved with Federal aid consists of 11.2 miles of untreated gravel, 11.7 miles of low-cost bituminous-mixed surface, 221.3 miles of Portland cement concrete, and 6.2 miles of block pavement, in addition to which there are bridges and approaches with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed during the year was $835,954.86, of which the Federal share was $406,222.78. The disbursement of Federal funds to the State was $594,597.88. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $91,051.91.

FLORIDA

The Federal-aid highway system includes 1,926 miles, of which 503.5 miles have been improved with Federal aid. Of the improved mileage, 54.3 miles were added during the year. At the close of the year 102.6 miles were under construction.

The mileage improved with Federal aid consists of 14.9 miles of graded and drained earth roads, 15.6 miles of untreated sand-clay, 1 mile of treated gravel, 85.4 miles of untreated macadam, 67 miles of treated macadam, 72.6 miles of bituminous macadam, 60.7 miles of bituminous concrete, 168 miles of Portland cement concrete, and 10.2 miles of block pavement, in addition to which there are bridges and approaches with a total length of 8.1 miles.

The total cost of all Federal-aid roads completed during the year was $1,381,290.93, of which the Federal share was $596,942.17. The disbursement of Federal funds to the State was $660,158.48. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,681,203.79.

GEORGIA

The Federal-aid highway system includes 5,554 miles, of which 2,703.3 miles have been improved with Federal aid. Of the improved mileage, 134.5 miles were added during the year. At the close of the year 150.8 miles were under construction, and 59.6 miles had been approved.

The mileage improved with Federal aid consists of 214.7 miles of graded and drained earth roads, 1,129.4 miles of untreated sand-clay, 441 miles of untreated gravel, 3.7 miles of treated gravel, 52.3 miles of untreated macadam, 88.5 miles of treated macadam, 207.3 miles of bituminous macadam, 54.2 miles of bituminous concrete, 481.5 miles of Portland cement concrete, and 0.5 mile of block pavement, in addition to which there are bridges and approaches with a total length of 30.2 miles.

The total cost of all Federal-aid roads completed during the year, including 41.4 miles of stage construction, was $2,910,553.68, of which the Federal share was $1,230,736.17. The disbursement of Federal funds to the State was $623,085.28. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,902,272.18.

IDAHO

The Federal-aid highway system includes 3,116 miles, of which 1,194.1 miles have been improved with Federal aid. Of the improved mileage, 77.1 miles were added during the year. At the close of the year 113 miles were under construction, and 54.3 miles had been approved.

The mileage improved with Federal aid consists of 180.8 miles of graded and drained earth roads, 582.3 miles of untreated gravel, 244.1 miles of untreated macadam, 28.5 miles of low-cost bituminous-mixed surface, 20.4 miles of bituminous macadam, 89.7 miles of bituminous concrete, and 44.6 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 3.7 miles.

The total cost of all Federal-aid roads completed during the year was $937,768.62, of which the Federal share was $565.258.96. The disbursement of Federal funds to the State was $574.315.68. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,175,024.06.

ILLINOIS

The Federal-aid highway system includes 6,650 miles, of which 2,056.1 miles have been improved with Federal aid. Of the improved mileage, 169 miles were added during the year. At the close of the year 454.4 miles were under construction, and 153.9 miles had been approved.

The mileage improved with Federal aid consists of 183.9 miles of graded and drained earth roads, 0.4 mile of untreated gravel, 3.3 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1,832.8 miles of Portland cement concrete, and 25.4 miles of block pavement, in addition to which there are bridges and approaches with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year was $5,021,954.42, of which the Federal share was $2,201,666.48. The disbursement of Federal funds to the State was $1,908,477.62. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $4,656,255.25.

INDIANA

The Federal-aid highway system includes 4,694 miles, of which 1,481.6 miles have been improved with Federal aid. Of the improved mileage, 214.7 miles were added during the year. At the close of the year 153.2 miles were under construction, and 9.9 miles had been approved.

The mileage improved with Federal aid consists of 16.9 miles of graded and drained earth roads, 90.2 miles of untreated gravel, 17 miles of bituminous macadam, 12 miles of bituminous concrete, 1,334.8 miles of Portland cement concrete, and 6.6 miles of block pavement, in addition to which there are bridges and approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year was $6,693,965.53, of which the Federal share was $3,142,358.52. The disbursement of Federal funds to the State was $2,295,345.32. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,473,551.58.

IOWA

The Federal-aid highway system includes 7,212 miles, of which 2,979.7 miles have been improved with Federal aid. Of the improved mileage, 66.8 miles were added during the year. At the close of the year 242.9 miles were under construction, and 11.8 miles had been approved.

The mileage improved with Federal aid consists of 1,201.5 miles of graded and drained earth roads, 521.1 miles of untreated gravel, 1,233.1 miles of Portland cement concrete, and 21.9 miles of block pavement, in addition to which there are bridges and approaches with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed during the year, including 146.6 miles of stage construction, was $5,075,345.20, of which the Federal share was $2,411,131.90. The disbursement of Federal funds to the State was $2,504,338.70. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,892.77.

KANSAS

The Federal-aid highway system includes 7,917 miles, of which 2,833.9 miles have been improved with Federal aid. Of the improved mileage, 324.3 miles were added during the year. At the close of the

year 276.5 miles were under construction, and 20.6 miles had been approved.

The mileage improved with Federal aid consists of 1,277.5 miles of graded and drained earth roads, 276.6 miles of untreated sand-clay, 239.7 miles of untreated gravel, 4.5 miles of untreated macadam, 129.9 miles of bituminous macadam, 3.5 miles of bituminous concrete, 722.2 miles of Portland cement concrete, and 166 miles of block pavement, in addition to which there are bridges and approaches with a total length of 14 miles.

The total cost of all Federal-aid roads completed during the year, including 16.9 miles of stage construction, was $4,022,635.69, of which the Federal share was $1,838,127.19. The disbursement of Federal funds to the State was $2,541,954.83. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,063,112.86.

KENTUCKY

The Federal-aid highway system includes 3,710 miles, of which 1,530.2 miles have been improved with Federal aid. Of the improved mileage, 218.9 miles were added during the year. At the close of the year 127.1 miles were under construction, and 50.5 miles had been approved.

The mileage improved with Federal aid consists of 682 miles of graded and drained earth roads, 390 miles of untreated gravel, 20.4 miles of untreated macadam, 50.3 miles of treated macadam, 84.3 miles of bituminous macadam, 115.2 miles of bituminous concrete, 180.1 miles of Portland-cement concrete, and 3.9 miles of block pavement, in addition to which there are bridges and approaches with a total length of 4 miles.

The total cost of all Federal-aid roads completed during the year, including 35.3 miles of stage construction, was $3,182,683.33, of which the Federal share was $1,522,746.58. The disbursement of Federal funds to the State was $1,537,194.33. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date, was $114,878.62.

LOUISIANA

The Federal-aid highway system includes 2,713 miles, of which 1,352.4 miles have been improved with Federal aid. Of the improved mileage, 46.7 miles were added during the year. At the close of the year 168.1 miles were under construction, and 49 miles had been approved.

The mileage improved with Federal aid consists of 35.1 miles of graded and drained earth roads, 1,219.8 miles of untreated gravel, 3.2 miles of bituminous macadam, 43 miles of bituminous concrete, and 39.8 miles of Portland-cement concrete, in addition to which there are bridges and approaches with a total length of 11.5 miles.

The total cost of all Federal-aid roads completed during the year, including 7.5 miles of reconstruction, was $739,997.12, of which the Federal share was $330,765.30. The disbursement of Federal funds to the State was $852,639.40. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date, was $1,224,288.48.

MAINE

The Federal-aid highway system includes 1,579 miles, of which 534.8 miles have been improved with Federal aid. Of the improved mileage, 54.3 miles were added during the year. At the close of the year 57.6 miles were under construction, and 23.9 miles had been approved.

The mileage improved with Federal aid consists of 222.8 miles of untreated gravel, 28.3 miles of treated gravel, 175.3 miles of bituminous macadam, and 107.8 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed during the year, including 1.9 miles of reconstruction, was $1,990,485.62, of which the Federal share was $713,957.89. The disbursement of Federal funds to the State was $1,187,526.36. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,354,501.03.

MARYLAND

The Federal-aid highway system includes 1,705 miles, of which 630.7 miles have been improved with Federal aid. Of the improved mileage, 34.1 miles were added during the year. At the close of the year 47.4 miles were under construction, and 26 miles had been approved.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of untreated gravel, 0.1 mile of untreated macadam, 3.9 miles of treated macadam, 224.9 miles of bituminous macadam, 31.5 miles of bituminous concrete, and 334.1 miles of Portland cement concrete.

The total cost of all Federal-aid roads completed during the year, including 14.7 miles of stage construction, and 3 miles of reconstruction, was $1,084,004.76, of which the Federal share was $502,002.20. The disbursement of Federal funds to the State was $466,652.87. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $5,543.03.

MASSACHUSETTS

The Federal-aid highway system includes 1,343 miles, of which 657.4 miles have been improved with Federal aid. Of the improved mileage, 89.6 miles were added during the year. At the close of the year 68.6 miles were under construction, and 11.3 miles had been approved.

The mileage improved with Federal aid consists of 0.5 mile of untreated gravel, 0.4 mile of treated gravel, 0.1 mile of untreated macadam, 2.8 miles of treated macadam, 22 miles of low-cost bituminous-mixed surface, 366.2 miles of bituminous macadam, 56.4 miles of bituminous concrete, and 204.4 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 4.6 miles.

The total cost of all Federal-aid roads completed during the year, including 0.7 mile of stage construction and 2.7 miles of reconstruction, was $4,416,602.77, of which the Federal share was

$1,468,754.17. The disbursement of Federal funds to the State was $1,546,517.25. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,944,255.39.

MICHIGAN

The Federal-aid highway system includes 5,238 miles, of which 1,605.2 miles have been improved with Federal aid. Of the improved mileage, 172.4 miles were added during the year. At the close of the year 261 miles were under construction, and 30.1 miles had been approved.

The mileage improved with Federal aid consists of 8.6 miles of graded and drained earth roads, 342.7 miles of untreated gravel, 16.3 miles of treated macadam, 10.4 miles of bituminous macadam, 69 miles of bituminous concrete, 1,155.4 miles of Portland cement concrete, and 0.4 mile of block pavement, in addition to which there are bridges and approaches with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed during the year, including 2.9 miles of stage construction, was $7,779,534.69, of which the Federal share was $3,020,745.34. The disbursement of Federal funds to the State was $2,300,913.73. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,782,145.14.

MINNESOTA

The Federal-aid highway system includes 6,885 miles, of which 3,936.1 miles have been improved with Federal aid. Of the improved mileage, 242.5 miles were added during the year. At the close of the year 469.7 miles were under construction and 19.4 miles had been approved.

The mileage improved with Federal aid consists of 1,000.6 miles of graded and drained earth roads, 11.1 miles of untreated sand-clay, 2,079 miles of untreated gravel, 17.6 miles of treated gravel, 32.7 miles of bituminous concrete, and 793.5 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 1.6 miles.

The total cost of all Federal-aid roads completed during the year, including 82.8 miles of stage construction, was $4,573,620.24, of which the Federal share was $1,786,351.44. The disbursement of Federal funds to the State was $2,192,899.80. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $46,352.03.

MISSISSIPPI

The Federal-aid highway system includes 3,632 miles, of which 1,820.7 miles have been improved with Federal aid. Of the improved mileage, 155.2 miles were added during the year. At the close of the year 62.7 miles were under construction and 0.1 mile had been approved.

The mileage improved with Federal aid consists of 294.6 miles of graded and drained earth roads, 15.8 miles of untreated sand-clay, 1,220.6 miles of untreated gravel, 11.1 miles of untreated macadam,

12.4 miles of bituminous concrete, 246.3 miles of Portland cement concrete, and 9.7 miles of block pavement, in addition to which there are bridges and approaches with a total length of 10.2 miles.

The total cost of all Federal-aid roads completed during the year, including 4.4 miles of stage construction, was $3,178,703.45, of which the Federal share was $1,550,795.82. The disbursement of Federal funds to the State was $745,258.17. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $3,527,955.68.

MISSOURI

The Federal-aid highway system includes 7,530 miles, of which 2,486.8 miles have been improved with Federal aid. Of the improved mileage, 217 miles were added during the year. At the close of the year 178.8 miles were under construction, and 61.6 miles had been approved.

The mileage improved with Federal aid consists of 392.3 miles of graded and drained earth roads, 752.8 miles of untreated gravel, 27.2 miles of untreated macadam, 43 miles of bituminous macadam, 20.1 miles of bituminous concrete, 1,220.1 miles of Portland cement concrete, and 20.9 miles of block pavement, in addition to which there are bridges and approaches with a total length of 10.4 miles.

The total cost of all Federal-aid roads completed during the year, including 138.8 miles of stage construction, was $10,177,544.47, of which the Federal share was $4,125,021.08. The disbursement of Federal funds to the State was $3,436,554.13. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $831,704.84.

MONTANA

The Federal-aid highway system includes 5,108 miles, of which 1,717.4 miles have been improved with Federal aid. Of the improved mileage, 214.1 miles were added during the year. At the close of the year 569.6 miles were under construction, and 90.2 miles had been approved.

The mileage improved with Federal aid consists of 210.2 miles of graded and drained earth roads, 1,442.9 miles of untreated gravel, 8.8 miles of low-cost bituminous-mixed surface, 12.5 miles of bituminous concrete, and 37 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 6 miles.

The total cost of all Federal-aid roads completed during the year, including 4.1 miles of stage construction, was $2,557,945.61, of which the Federal share was $1,565,807.28. The disbursement of Federal funds to the State was $2,571,899.09. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $3,540,456.15.

NEBRASKA

The Federal-aid highway system includes 5,530 miles, of which 3,669.1 miles have been improved with Federal aid. Of the improved mileage, 137.8 miles were added during the year. At the

close of the year 418.8 miles were under construction, and 54.7 miles had been approved.

The mileage improved with Federal aid consists of 504.6 miles of graded and drained earth roads, 3,027.1 miles of untreated sand-clay, 0.8 mile of treated sand-clay, 3.8 miles of low-cost bituminous-mixed surface, 14.6 miles of bituminous concrete, 90.1 miles of Portland cement concrete, and 19.6 miles of block pavement, in addition to which there are bridges and approaches with a total length of 8.5 miles.

The total cost of all Federal-aid roads completed during the year, including 161.4 miles of stage construction, was $2,280,225.35, of which the Federal share was $1,078,362.13. The disbursement of Federal funds to the State was $1,980,717.15. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,176,337.14.

NEVADA

The Federal-aid highway system includes 1,565 miles, of which 1,219.2 miles have been improved with Federal aid. Of the improved mileage, 147.3 miles were added during the year. At the close of the year 122.1 miles were under construction.

The mileage improved with Federal aid consists of 46.8 miles of graded and drained earth roads, 805.1 miles of untreated gravel, 14.3 miles of treated gravel, 282.5 miles of low-cost bituminous-mixed surface, 20.6 miles of bituminous macadam, 1.9 miles of bituminous concrete, and 45.2 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 2.8 miles.

The total cost of all Federal-aid roads completed during the year, including 191.9 miles of stage construction, was $1,494,392.50, of which the Federal share was $1,312,039.17. The disbursement of Federal funds to the State was $996,033.53. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $773,969.02.

NEW HAMPSHIRE

The Federal-aid highway system includes 991 miles, of which 352.7 miles have been improved with Federal aid. Of the improved mileage, 19 miles were added during the year. At the close of the year 36.6 miles were under construction.

The mileage improved with Federal aid consists of 97.5 miles of untreated macadam, 74.8 miles of treated macadam, 86.1 miles of bituminous macadam, 35.9 miles of bituminous concrete, and 54.5 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 3.9 miles.

The total cost of all Federal-aid roads completed during the year, including 1 mile of stage construction and 2.1 miles of reconstruction, was $833,461.61, of which the Federal share was $319,996.37. The disbursement of Federal funds to the State was $464,211.66. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $221,369.45.

NEW JERSEY

The Federal-aid highway system includes 1,186 miles, of which 507.8 miles have been improved with Federal aid. Of the improved mileage, 45.1 miles were added during the year. At the close of the year 66.7 miles were under construction.

The mileage improved with Federal aid consists of 11.8 miles of graded and drained earth roads, 6 miles of untreated gravel, 0.2 mile of treated macadam, 0.5 mile of bituminous macadam, 22.5 miles of bituminous concrete, and 464.4 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed during the year was $3,757,925.87, of which the Federal share was $677,880. The disbursement of Federal funds to the State was $629,055. The unobligated balance available on June 30. 1930, of all appropriations authorized and apportioned up to that date was $977,248.76.

NEW MEXICO

The Federal-aid highway system includes 3,466 miles, of which 1,904.4 miles have been improved with Federal aid. Of the improved mileage, 87.5 miles were added during the year. At the close of the year, 236 miles were under construction and 32.6 miles had been approved.

The mileage improved with Federal aid consists of 265.7 miles of graded and drained earth roads, 27.3 miles of untreated sand-clay, 1,506.9 miles of untreated gravel, 17.2 miles of low-cost bituminous-mixed surface, 0.7 mile of bituminous concrete, and 82.5 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 0.7 mile of stage construction, was $1,331,927.95, of which the Federal share was $838,102.84. The disbursement of Federal funds to the State was $827,764.88. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $969,531.76.

NEW YORK

The Federal-aid highway system includes 5,558 miles, of which 2,491 miles have been improved with Federal aid. Of the improved mileage, 306.9 miles were added during the year. At the close of the year, 300.4 miles were under construction and 83.6 miles had been approved.

The mileage improved with Federal aid consists of 46.9 miles of graded and drained earth roads, 76.4 miles of untreated gravel, 402.5 miles of bituminous macadam, 11.5 miles of bituminous concrete, 1,951 miles of Portland cement concrete. and 0.7 mile of block pavement, in addition to which there are bridges and approaches with a total length of 2 miles.

The total cost of all Federal-aid roads completed during the year was $12,240,775.13, of which the Federal share was $4,431,341.77. The disbursement of Federal funds to the State was $4,078,108.85. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $7,315,347.86.

NORTH CAROLINA

The Federal-aid highway system includes 4,219 miles, of which 1,780.6 miles have been improved with Federal aid. Of the improved mileage, 90.8 miles were added during the year. At the close of the year 175.5 miles were under construction, and 25.8 miles had been approved.

The mileage improved with Federal aid consists of 87.9 miles of graded and drained earth roads, 474.6 miles of untreated sand-clay, 78 miles of untreated gravel, 19.6 miles of untreated macadam, 35.6 miles of bituminous macadam, 256.9 miles of bituminous concrete, and 824 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 4 miles.

The total cost of all Federal-aid roads completed during the year, including 9.5 miles of stage construction, was $1,694,550.53, of which the Federal share was $798,658.46. The disbursement of Federal funds to the State was $711,610.60. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $2,560,469.31.

NORTH DAKOTA

The Federal-aid highway system includes 7,424 miles, of which 4,262.6 miles have been improved with Federal aid. Of the improved mileage, 577.2 miles were added during the year. At the close of the year 468.3 miles were under construction, and 151.3 miles had been approved.

The mileage improved with Federal aid consists of 1,375.8 miles of graded and drained earth roads, 10.8 miles of untreated sand-clay, 2,779.8 miles of untreated gravel, 80.6 miles of treated gravel, 1.1 miles of bituminous concrete, and 6.6 miles of Portland-cement concrete, in addition to which there are bridges and approaches with a total length of 7.9 miles.

The total cost of all Federal-aid roads completed during the year, including 392.5 miles of stage construction, was $3,931,493.45, of which the Federal share was $1,630,756.04. The disbursement of Federal funds to the State was $1,236,250.08. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,452,524.56.

OHIO

The Federal-aid highway system includes 5,899 miles, of which 2,190.4 miles have been improved with Federal aid. Of the improved mileage, 217.8 miles were added during the year. At the close of the year 403 miles were under construction and 83.1 miles had been approved.

The mileage improved with Federal aid consists of 120.6 miles of graded and drained earth roads, 9.4 miles of untreated gravel, 110.7 miles of untreated macadam, 26.1 miles of treated macadam, 356.5 miles of bituminous macadam, 156.1 miles of bituminous concrete, 883.8 miles of Portland cement concrete, and 522.7 miles of block pavement, in addition to which there are bridges and approaches with a total length of 4.5 miles.

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The total cost of all Federal-aid roads completed during the year was $7,966,093.72, of which the Federal share was $3,298,783.47. The disbursement of Federal funds to the State was $2,455,602.56. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $939,205.53.

OKLAHOMA

The Federal-aid highway system includes 5,622 miles, of which 1,890.4 miles have been improved with Federal aid. Of the improved mileage, 119.3 miles were added during the year. At the close of the year 172.6 miles were under construction and 92.7 miles had been approved.

The mileage improved with Federal aid consists of 378.5 miles of graded and drained earth roads, 0.7 mile of untreated sand-clay, 559.2 miles of untreated gravel, 8.3 miles of treated gravel, 28.8 miles of untreated macadam, 0.5 mile of bituminous macadam, 151 miles of bituminous concrete, 741.1 miles of Portland cement concrete, and 8.9 miles of block pavement, in addition to which there are bridges and approaches with a total length of 13.4 miles.

The total cost of all Federal-aid roads completed during the year, including 59.1 miles of stage construction, was $3,764,985.03, of which the Federal share was $1,697,687.86. The disbursement of Federal funds to the State was $2,080,335.52. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $184,302.92.

OREGON

The Federal-aid highway system includes 3,247 miles, of which 1,150.4 miles have been improved with Federal aid. Of the improved mileage, 87.9 miles were added during the year. At the close of the year 289.9 miles were under construction, and 49.1 miles had been approved.

The mileage improved with Federal aid consists of 235.3 miles of graded and drained earth roads, 711.5 miles of untreated gravel, 25.6 miles of untreated macadam, 14.2 miles of bituminous macadam, 64.2 miles of bituminous concrete, and 94.7 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 4.9 miles.

The total cost of all Federal-aid roads completed during the year was $1,129,094.63, of which the Federal share was $597,022.73. The disbursement of Federal funds to the State was $703,274.47. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $288,573.31.

PENNSYLVANIA

The Federal-aid highway system includes 5,487 miles, of which 2,341.9 miles have been improved with Federal aid. Of the improved mileage, 274.3 miles were added during the year. At the close of the year 225.8 miles were under construction, and 87.1 miles had been approved.

The mileage improved with Federal aid consists of 156.9 miles of graded and drained earth roads, 10.6 miles of treated macadam,

7.7 miles of bituminous macadm, 98.4 miles of bituminous concrete, 2,026.8 miles of Portland cement concrete, and 39.5 miles of block pavement, in addition to which there are bridges and approaches with a total length of 2 miles.

The total cost of all Federal-aid roads completed during the year was $15,902,008.93, of which the Federal share was $4,439,697.96. The disbursement of Federal funds to the State was $3,710,013.31. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,082,376.94.

RHODE ISLAND

The Federal-aid highway system includes 417 miles, of which 184.7 miles have been improved with Federal aid. Of the improved mileage, 19.5 miles were added during the year. At the close of the year 28.2 miles were under construction.

The mileage improved with Federal aid consists of 1.8 miles of treated macadam, 57.1 miles of bituminous macadam, 48.1 miles of bituminous concrete, and 76.8 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 0.9 mile.

The total cost of all Federal-aid roads completed during the year was $910,987.88, of which the Federal share was $326,666.13. The disbursement of Federal funds to the State was $171,477.02. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $588,570.42.

SOUTH CAROLINA

The Federal-aid highway system includes 3,232 miles, of which 1,868.5 miles have been improved with Federal aid. Of the improved mileage, 98.9 miles were added during the year. At the close of the year 178.6 miles were under construction, and 27.2 miles had been approved.

The mileage improved with Federal aid consists of 43.3 miles of graded and drained earth roads, 1,202 miles of untreated sand-clay, 107.7 miles of untreated gravel, 3.1 miles of bituminous macadam, 186 miles of bituminous concrete, and 303.7 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 22.7 miles.

The total cost of all Federal-aid roads completed during the year, including 45 miles of stage construction, was $3,511,295.63, of which the Federal share was $1,016,308.31. The disbursement of Federal funds to the State was $926,038.22. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $97,283.99.

SOUTH DAKOTA

The Federal-aid highway system includes 6,148 miles, of which 3,445.1 miles have been improved with Federal aid. Of the improved mileage, 243.1 miles were added during the year. At the close of the year 596.1 miles were under construction, and 44 miles had been approved.

The mileage improved with Federal aid consists of 204.5 miles of graded and drained earth roads, 36 miles of untreated sand-clay, 15.7 miles of treated sand-clay, 3,162.6 miles of untreated gravel, 9.5 miles of low-cost bituminous-mixed surface, and 12.9 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 3.9 miles.

The total cost of all Federal-aid roads completed during the year, including 42.2 miles of stage construction, was $1,594,466.64, of which the Federal share was $852,372.53. The disbursement of Federal funds to the State was $1,162,383.12. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,062,892.43.

TENNESSEE

The Federal-aid highway system includes 3,521 miles, of which 1,260.9 miles have been improved with Federal aid. Of the improved mileage, 125.2 miles were added during the year. At the close of the year 144.8 miles were under construction, and 82.3 miles had been approved.

The mileage improved with Federal aid consists of 104.7 miles of graded and drained earth roads, 106.3 miles of untreated gravel, 61.5 miles of untreated macadam, 361.7 miles of bituminous macadam, 121.6 miles of bituminous concrete, and 497.9 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 7.2 miles.

The total cost of all Federal-aid roads completed during the year was $3,088,719.17, of which the Federal share was $1,443,055.24. The disbursement of Federal funds to the State was $1,459,546.34. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,552,381.84.

TEXAS

The Federal-aid highway system includes 11,722 miles, of which 6,835.6 miles have been improved with Federal aid. Of the improved mileage, 636 miles were added during the year. At the close of the year 496.1 miles were under construction, and 101.6 miles had been approved.

The mileage improved with Federal aid consists of 835.3 miles of graded and drained earth roads, 39.4 miles of untreated sand-clay, 2,857.6 miles of untreated gravel, 292.2 miles of treated gravel, 72.7 miles of untreated macadam, 119.7 miles of treated macadam, 19.8 miles of low-cost bituminous-mixed surface, 521.8 miles of bituminous macadam, 709.6 miles of bituminous concrete, 1,307.1 miles of Portland cement concrete, and 30.2 miles of block pavement, in addition to which there are bridges and approaches with a total length of 30.2 miles.

The total cost of all Federal-aid roads completed during the year, including 368.1 miles of stage construction, was $16,492,620.38, of which the Federal share was $7,347,398.73. The disbursement of Federal funds to the State was $6,292,484.66. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $4,647,819.57.

UTAH

The Federal-aid highway system includes 1,751 miles, of which 981.2 miles have been improved with Federal aid. Of the improved mileage, 73.7 miles were added during the year. At the close of the year 67.1 miles were under construction and 44.9 miles had been approved.

The mileage improved with Federal aid consists of 110.9 miles of graded and drained earth roads, 146.8 miles of untreated gravel, 3.4 miles of treated gravel, 560.9 miles of untreated macadam, 39.2 miles of low-cost bituminous-mixed surface, 0.8 mile of bituminous macadam, 10.6 miles of bituminous concrete, and 105.9 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 2.7 miles.

The total cost of all Federal-aid roads completed during the year was $1,754,707.02, of which the Federal share was $1,138,237.82. The disbursement of Federal funds to the State was $730,519.47. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $662,833.17.

VERMONT

The Federal-aid highway system includes 1,043 miles, of which 255.6 miles have been improved with Federal aid. Of the improved mileage, 29.4 miles were added during the year. At the close of the year 45.1 miles were under construction, and 5.7 miles had been approved.

The mileage improved with Federal aid consists of 106.6 miles of untreated gravel, 2 miles of treated gravel, 1.2 miles of untreated macadam, 51.6 miles of bituminous macadam, and 89.6 miles of Portland-cement concrete, in addition to which there are bridges and approaches with a total length of 4.6 miles.

The total cost of all Federal-aid roads completed during the year was $1,465,991.89, of which the Federal share was $497,157.48. The disbursement of Federal funds to the State was $366,821.03. All appropriations authorized and apportioned up to June 30, 1930, had been obligated on that date.

VIRGINIA

The Federal-aid highway system includes 3,565 miles, of which 1,467.9 miles have been improved with Federal aid. Of the improved mileage, 137.3 miles were added during the year. At the close of the year 216.7 miles were under construction, and 28 miles had been approved.

The mileage improved with Federal aid consists of 85 miles of graded and drained earth roads, 216.3 miles of untreated sand-clay, 101.3 miles of untreated gravel, 133.8 miles of untreated macadam, 9.4 miles of treated macadam, 374.1 miles of bituminous macadam, 39.8 miles of bituminous concrete, and 502.1 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 6.1 miles.

The total cost of all Federal-aid roads completed during the year, including 21.7 miles of stage construction, was $3,984,741.95,

of which the Federal share was $1,627,334.71. The disbursement of Federal funds to the State was $1,090,622.55. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $691,693.83.

WASHINGTON

The Federal-aid highway system includes 3,033 miles, of which 934.6 miles have been improved with Federal aid. Of the improved mileage, 101.1 miles were added during the year. At the close of the year 126.3 miles were under construction, and 2.1 miles had been approved.

The mileage improved with Federal aid consists of 179.4 miles of graded and drained earth roads, 420.4 miles of untreated gravel, and 329.8 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 5 miles.

The total cost of all Federal-aid roads completed during the year, including 10.4 miles of stage construction, was $4,176,691.12, of which the Federal share was $1,493,032.99. The disbursement of Federal funds to the State was $1,377,438.14. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,211,773.29.

WEST VIRGINIA

The Federal-aid highway system includes 2,214 miles, of which 710.1 miles have been improved with Federal aid. Of the improved mileage, 39 miles were added during the year. At the close of the year 102.8 miles were under construction, and 20.5 miles had been approved.

The mileage improved with Federal aid consists of 249.6 miles of graded and drained earth roads, 28.3 miles of untreated gravel, 14.2 miles of untreated macadam, 0.6 mile of treated macadam, 185 miles of bituminous macadam, 28.7 miles of bituminous concrete, 190.2 miles of Portland cement concrete, and 11.4 miles of block pavement, in addition to which there are bridges and approaches with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed during the year, including 17.6 miles of stage construction, was $1,968,983.06, of which the Federal share was $744,716.04. The disbursement of Federal funds to the State was $874,504.14. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $628,588.82.

WISCONSIN

The Federal-aid highway system includes 5,493 miles, of which 2,246.2 miles have been improved with Federal aid. Of the improved mileage, 288.6 miles were added during the year. At the close of the year 245.7 miles were under construction and 28 miles had been approved.

The mileage improved with Federal aid consists of 144.2 miles of graded and drained earth roads, 23.8 miles of untreated sand-clay, 1,030.2 miles of untreated gravel, 19.9 miles of treated gravel, 13.7 miles of bituminous macadam, 0.4 mile of bituminous concrete, and

1,007.1 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 6.9 miles.

The total cost of all Federal-aid roads completed during the year, including 31.7 miles of stage construction, was $9,029,204.63, of which the Federal share was $4,154,568.49. The disbursement of Federal funds to the State was $3,058,505.08. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $816,349.40.

WYOMING

The Federal-aid highway system includes 3,498 miles, of which 1,708.7 miles have been improved with Federal aid. Of the improved mileage, 120.4 miles were added during the year. At the close of the year 241.1 miles were under construction and 13.7 miles had been approved.

The mileage improved with Federal aid consists of 531.6 miles of graded and drained earth roads, 10.6 miles of untreated sand-clay, 1,060.2 miles of untreated gravel, 61.9 miles of low-cost bituminous-mixed surface, 22.1 miles of bituminous concrete, and 15.9 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 6.4 miles.

The total cost of all Federal-aid roads completed during the year, including 36.3 miles of stage construction, was $1,154,162.71, of which the Federal share was $693,363.60. The disbursement of Federal funds to the State was $958,322.93. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $588,414.28.

HAWAII

The Federal-aid highway system includes 217 miles, of which 41.2 miles have been improved with Federal aid. Of the improved mileage, 1.7 miles were added during the year. At the close of the year 21.5 miles were under construction and 9.2 miles had been approved.

The mileage improved with Federal aid consists of 1.7 miles of graded and drained earth roads, 6.9 miles of bituminous macadam, 13.3 miles of bituminous concrete, and 19 miles of Portland cement concrete, in addition to which there are bridges and approaches with a total length of 0.3 mile.

The total cost of all Federal-aid roads completed during the year was $105,732.15, of which the Federal share was $25,227. The disbursement of Federal funds to the State was $79,118.49. The unobligated balance available on June 30, 1930, of all appropriations authorized and apportioned up to that date was $1,568,624.59.

FEDERAL-AID STATISTICS

Statistical information relative to the apportionment, obligation, and disbursement of Federal aid during the fiscal year 1930, the cost of roads completed and the estimated cost of roads under construction, and the type of the roads completed and under construction, etc., is given in Tables 24 to 36, inclusive.

TABLE 24.—*Mileage of the designated Federal aid highway system in each State and mileage improved with Federal aid to June 30, 1930*

State	Mileage of designated Federal-aid highway system	Mileage completed with Federal aid to June 30, 1930	State	Mileage of designated Federal-aid highway system	Mileage completed with Federal aid to June 30, 1930
Alabama	3,884	2,153.8	New Hampshire	991	352.7
Arizona	1,979	810.3	New Jersey	1,186	507.8
Arkansas	5,019	1,741.4	New Mexico	3,466	1,904.4
California	4,889	1,880.2	New York	5,558	2,491.0
Colorado	3,332	1,208.1	North Carolina	4,219	1,780.6
Connecticut	836	243.3	North Dakota	7,424	4,262.6
Delaware	550	251.0	Ohio	5,899	2,190.4
Florida	1,926	503.5	Oklahoma	5,622	1,890.4
Georgia	5,554	2,703.3	Oregon	3,247	1,150.4
Idaho	3,116	1,194.1	Pennsylvania	5,487	2,341.9
Illinois	6,650	2,056.1	Rhode Island	417	184.7
Indiana	4,694	1,481.6	South Carolina	3,232	1,868.5
Iowa	7,212	2,979.7	South Dakota	6,148	3,445.1
Kansas	7,917	2,833.9	Tennessee	3,521	1,260.9
Kentucky	3,710	1,530.2	Texas	11,722	6,835.6
Louisiana	2,713	1,352.4	Utah	1,751	981.2
Maine	1,579	534.8	Vermont	1,043	255.6
Maryland	1,705	630.7	Virginia	3,565	1,467.9
Massachusetts	1,343	657.4	Washington	3,033	934.6
Michigan	5,238	1,605.2	West Virginia	2,214	710.1
Minnesota	6,885	3,936.1	Wisconsin	5,493	2,246.2
Mississippi	3,632	1,820.7	Wyoming	3,498	1,708.7
Missouri	7,530	2,486.8	Hawaii	217	41.2
Montana	5,108	1,717.4			
Nebraska	5,530	3,669.1	Total	193,049	84,012.8
Nevada	1,565	1,219.2			

TABLE 25.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction completed during the fiscal year 1930*

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
Alabama	$3,073,848.12	$1,443,082.40	194.2	14.5	208.7
Arizona	1,535,443.88	1,379,714.19	43.1	46.6	89.7
Arkansas	3,401,174.82	1,685,445.48	102.6	14.3	116.9
California	11,396,353.24	5,087,674.79	335.6	20.0	355.6
Colorado	1,883,264.93	994,769.96	72.3	38.1	110.4
Connecticut	770,370.16	255,295.83	14.1	----------	14.1
Delaware	835,954.86	406,222.78	45.2	----------	45.2
Florida	1,381,290.93	596,942.17	54.3	----------	54.3
Georgia	2,910,553.68	1,230,736.17	134.5	41.4	175.9
Idaho	937,768.62	565,258.96	77.1	----------	77.1
Illinois	5,021,954.42	2,201,666.48	169.0	----------	169.0
Indiana	6,693,965.53	3,142,358.52	214.7	----------	214.7
Iowa	5,075,345.20	2,411,131.90	66.8	146.6	213.4
Kansas	4,022,635.69	1,838,127.19	324.3	16.9	341.2
Kentucky	3,182,683.33	1,522,746.58	218.9	35.3	254.2
Louisiana	739,997.12	330,765.30	46.7	----------	46.7
Maine	1,897,734.54	684,782.89	54.3	----------	54.3
Maryland	947,200.70	457,092.20	34.1	14.7	48.8
Massachusetts	4,258,302.47	1,427,414.17	89.6	.7	90.3
Michigan	7,779,534.69	3,020,745.34	172.4	2.9	175.3
Minnesota	4,573,620.24	1,786,351.44	242.5	82.8	325.3
Mississippi	3,178,703.45	1,550,795.82	155.2	4.4	159.6
Missouri	10,177,544.47	4,125,021.08	217.0	138.8	355.8
Montana	2,557,945.61	1,565,807.28	214.1	4.1	218.2
Nebraska	2,280,225.35	1,078,362.13	137.8	161.4	299.2
Nevada	1,494,392.50	1,312,039.17	147.3	191.9	339.2
New Hampshire	683,180.62	239,036.37	19.0	1.0	20.0
New Jersey	3,757,925.87	677,880.00	45.1	----------	45.1
New Mexico	1,331,927.95	838,102.84	87.5	.7	88.2
New York	12,240,775.13	4,431,341.77	306.9	----------	306.9
North Carolina	1,694,550.53	798,658.46	90.8	9.5	100.3
North Dakota	3,931,493.45	1,630,756.04	577.2	392.5	969.7
Ohio	7,966,093.72	3,298,783.47	217.8	----------	217.8
Oklahoma	3,764,985.03	1,697,687.86	119.3	59.1	178.4
Oregon	1,129,094.63	597,022.73	87.9	----------	87.9
Pennsylvania	15,902,008.93	4,439,697.96	274.3	----------	274.3
Rhode Island	910,987.88	326,666.13	19.5	----------	19.5
South Carolina	3,511,295.63	1,016,308.31	98.9	45.0	143.9

TABLE 25.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction completed during the fiscal year 1930*—Continued

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
South Dakota	$1,594,466.64	$852,372.53	243.1	42.2	285.3
Tennessee	3,088,719.17	1,443,055.24	125.2		125.2
Texas	16,492,620.38	7,347,398.73	636.0	368.1	1,004.1
Utah	1,754,707.02	1,138,237.82	73.7		73.7
Vermont	1,465,991.89	497,157.48	29.4		29.4
Virginia	3,984,741.95	1,627,334.71	137.3	21.7	159.0
Washington	4,176,691.12	1,493,032.99	101.1	10.4	111.5
West Virginia	1,968,983.06	744,716.04	39.0	17.6	56.6
Wisconsin	9,029,204.63	4,154,568.49	288.6	31.7	320.3
Wyoming	1,154,162.71	693,363.60	120.4	36.3	156.7
Hawaii	105,732.15	25,227.00	1.7		1.7
Total	193,648,148.64	82,158,756.79	7,317.4	2,011.2	9,328.6

TABLE 26.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage improvement, under construction on June 30, 1930, by States*

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$2,326,218.40	$1,148,172.11	83.2	22.2	105.4
Arizona	4,114,720.89	3,088,393.26	136.5	149.1	285.6
Arkansas	5,523,331.76	2,530,094.42	142.9	46.2	189.1
California	7,170,064.91	2,901,983.78	119.4	27.8	147.2
Colorado	4,989,906.87	2,614,893.56	193.6	28.3	221.9
Connecticut	2,351,390.33	1,047,625.20	10.9		10.9
Delaware	900,925.60	357,666.32	24.9		24.9
Florida	5,127,463.61	2,358,944.67	97.1	5.5	102.6
Georgia	3,140,227.85	1,525,964.76	118.6	32.2	150.8
Idaho	1,315,433.28	793,224.26	85.2	27.8	113.0
Illinois	15,980,580.76	7,088,161.17	454.4		454.4
Indiana	4,953,074.92	2,363,937.39	153.2		153.2
Iowa	7,129,677.69	3,036,286.94	66.0	176.9	242.9
Kansas	5,640,308.69	2,707,334.03	248.7	27.8	276.5
Kentucky	3,736,246.74	1,638,751.70	121.6	5.5	127.1
Louisiana	4,992,472.59	2,432,542.49	153.8	14.3	168.1
Maine	2,327,133.99	869,119.44	57.6		57.6
Maryland	1,174,932.65	561,046.93	34.8	6.7	41.5
Massachusetts	4,280,043.25	1,350,586.54	66.0		66.0
Michigan	10,006,110.54	4,233,567.45	230.6	30.4	261.0
Minnesota	10,791,550.43	3,818,278.31	232.2	237.5	469.7
Mississippi	1,795,493.20	691,571.41	55.0	7.7	62.7
Missouri	7,687,851.27	2,665,580.20	117.5	61.3	178.8
Montana	7,874,376.59	4,608,614.27	525.9	43.7	569.6
Nebraska	7,382,359.82	3,442,551.75	272.9	145.9	418.8
Nevada	802,672.12	713,174.12		122.1	122.1
New Hampshire	1,542,914.69	552,093.03	36.6		36.6
New Jersey	5,923,349.51	1,476,271.32	66.7		66.7
New Mexico	3,711,585.77	2,433,941.63	185.3	50.7	236.0
New York	22,301,867.76	4,499,355.00	300.4		300.4
North Carolina	3,352,750.01	1,652,180.40	146.6	28.9	175.5
North Dakota	1,987,394.70	1,057,103.34	340.5	127.8	468.3
Ohio	20,373,300.95	6,579,243.04	367.8	35.2	403.0
Oklahoma	3,804,215.31	1,701,181.01	116.4	47.7	164.1
Oregon	5,343,938.89	3,150,289.24	204.5	85.4	289.9
Pennsylvania	16,972,451.08	4,590,035.23	211.7	14.1	225.8
Rhode Island	1,960,716.15	668,452.68	28.2		28.2
South Carolina	4,495,500.70	1,927,574.94	98.3	80.3	178.6
South Dakota	4,526,179.47	2,422,855.94	454.1	142.0	596.1
Tennessee	3,278,768.07	1,518,961.84	132.3	12.5	144.8
Texas	12,367,394.51	5,019,494.74	376.3	119.8	496.1
Utah	1,172,923.88	810,322.47	56.3	10.8	67.1
Vermont	2,165,910.24	756,716.81	42.5	1.2	43.7
Virginia	4,290,724.92	2,021,632.97	203.1	13.6	216.7
Washington	3,992,309.81	1,713,300.00	96.5	29.8	126.3
West Virginia	3,474,452.68	1,322,067.98	75.0	27.8	102.8
Wisconsin	7,729,781.66	3,114,270.98	197.6	48.1	245.7
Wyoming	2,122,570.69	1,382,750.59	148.5	92.6	241.1
Hawaii	853,565.90	359,459.43	21.5		21.5
Total	271,259,136.10	111,317,626.09	7,709.2	2,187.2	9,896.4

TABLE 27.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage improvement, approved for construction, as of June 30, 1930, by States*

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$13,545.40	$6,772.70			
Arizona	116,572.12	87,767.12		15.8	15.8
Arkansas	1,759,692.74	879,846.76	86.4	3.5	89.9
California	1,577,783.43	698,070.27	36.1	2.1	38.2
Colorado	1,232,562.53	617,597.98	29.0	69.0	98.0
Connecticut	446,379.45	117,900.00	7.9		7.9
Delaware	732,886.27	362,874.26	41.2		41.2
Georgia	2,962,085.96	1,360,367.13	59.6	68.4	128.0
Idaho	996,404.66	541,576.25	54.3	42.4	96.7
Illinois	6,282,202.65	2,808,075.49	153.9	63.5	217.4
Indiana	241,360.20	120,680.10	9.9		9.9
Iowa	1,140,139.79	475,042.91	11.8	27.8	39.6
Kansas	645,979.77	321,602.02	20.6	89.5	110.1
Kentucky	4,738,366.79	2,265,599.85	50.5	228.7	279.2
Louisiana	1,654,549.25	805,908.66	49.0	11.4	60.4
Maine	855,359.95	303,619.53	23.9		23.9
Maryland	883,765.93	441,838.21	26.0		26.0
Massachusetts	2,465,209.61	444,715.17	11.3		11.3
Michigan	824,037.67	363,275.00	30.1		30.1
Minnesota	1,232,803.68	490,675.40	19.4	32.3	51.7
Mississippi	48,835.05	24,417.52	.1		.1
Missouri	3,642,322.65	1,248,339.72	61.6	27.7	89.3
Montana	1,120,677.78	641,330.56	90.2	40.7	130.9
Nebraska	1,578,049.64	636,872.07	54.7	91.1	145.8
Nevada	348,831.87	307,040.69		81.0	81.0
New Mexico	643,139.21	479,303.52	32.6	1.9	34.5
New York	7,348,800.00	1,251,572.50	83.6		83.6
North Carolina	845,693.09	401,143.99	25.8	1.9	27.7
North Dakota	1,221,468.57	605,444.83	151.3	207.1	358.4
Ohio	5,055,233.63	1,732,197.73	83.1	13.1	96.2
Oklahoma	3,192,412.33	1,482,314,49	92.7	49.7	142.4
Oregon	819,262.95	490,778.04	49.1		49.1
Pennsylvania	6,603,495.13	1,978,331.84	87.1		87.1
South Carolina	1,463,356.75	529,064.20	27.2	26.2	53.4
South Dakota	586,204.87	368,755.17	44.0	70.6	114.6
Tennessee	2,817,321.13	1,107,295.27	82.3	38.2	120.5
Texas	2,945,441.96	1,207,057.26	101.6	52.7	154.3
Utah	704,739.73	516,652.55	44.9	78.8	123.7
Vermont	316,892.92	45,829.37	5.7		5.7
Virginia	833,708.70	395,539.94	28.0		28.0
Washington	248,056.42	144,900.00	2.1	6.5	8.6
West Virginia	1,184,345.87	386,995.23	20.5	17.2	37.7
Wisconsin	992,121.83	424,875.00	28.0		28.0
Wyoming	453,127.23	339,821.63	13.7	63.2	76.9
Hawaii	226,820.16	113,414.57	9.2		9.2
Total	76,042,044.32	30,373,092.50	1,940.0	1,522.0	3,462.0

TABLE 28.—*Mileage of Federal-aid roads improved, as of June 30, 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama	259.7	523.2		940.1	4.4		20.8		62.8	104.3	228.6		9.9	2,153.8
Arizona	80.2	58.8		462.0				55.8		38.1	109.3		6.1	810.3
Arkansas	86.3			1,029.4	6.4	41.5	110.6			257.9	197.4		11.9	1,741.4
California	382.5			468.7		22.5		133.6	96.8	174.7	590.8		10.6	1,880.2
Colorado	200.5	67.1		458.7		101.2		47.7		13.1	306.1		13.7	1,208.1
Connecticut				.2		17.2			39.7	.6	181.6		4.0	243.3
Delaware				11.2				11.7			221.3	6.2	.6	251.0
Florida	14.9	15.6			1.0	85.4	67.0		72.6	60.7	168.0	10.2	8.1	503.5
Georgia	214.7	1,129.4		441.0	3.7	52.3	88.5		207.3	54.2	481.5	.5	30.2	2,703.3
Idaho	180.8			582.3		244.1		28.5	20.4	89.7	44.6		3.7	1,194.1
Illinois	183.9			.4					3.3	8.1	1,832.8	25.4	2.2	2,056.1
Indiana	16.9			90.2					17.0	12.0	1,334.8	6.6	4.1	1,481.6
Iowa	1,201.5			521.1							1,233.1	21.9	2.1	2,979.7
Kansas	1,277.5	276.6		239.7		4.5			129.9	3.5	722.2	166.0	14.0	2,833.9
Kentucky	682.0			390.0		20.4	50.3		84.3	115.2	180.1	3.9	4.0	1,530.2
Louisiana	35.1			1,219.8					3.2	43.0	39.8		11.5	1,352.4
Maine				222.8	28.3				175.3		107.8		.6	534.8
Maryland	4.7			31.5		.1	3.9		224.9	31.5	334.1			630.7
Massachusetts				.5	.4	.1	2.8	22.0	366.2	56.4	204.4		4.6	657.4
Michigan	8.6			342.7			16.3		10.4	69.0	1,155.4	.4	2.4	1,605.2
Minnesota	1,000.6	11.1		2,079.0	17.6					32.7	793.5		1.6	3,936.1
Mississippi	294.6	15.8		1,220.6		11.1				12.4	246.3	9.7	10.2	1,820.7
Missouri	392.3			752.8		27.2			43.0	20.1	1,220.1	20.9	10.4	2,486.8
Montana	210.2			1,442.9				8.8		12.5	37.0		6.0	1,717.4
Nebraska	504.6	3,027.1	0.8					3.8		14.6	90.1	19.6	8.5	3,669.1
Nevada	46.8			805.1	14.3			282.5	20.6	1.9	45.2		2.8	1,219.2
New Hampshire						97.5	74.8		86.1	35.9	54.5		3.9	352.7
New Jersey	11.8			6.0			.2		.5	22.5	464.4		2.4	507.8
New Mexico	265.7	27.3		1,506.9				17.2		.7	82.5		4.1	1,904.4
New York	46.9			76.4					402.5	11.5	1,951.0	.7	2.0	2,491.0
North Carolina	87.9	474.6		78.0		19.6			35.6	256.9	824.0		4.0	1,780.6
North Dakota	1,375.8	10.8		2,779.8	80.6					1.1	6.6		7.9	4,262.6
Ohio	120.6			9.4		110.7	26.1		356.5	156.1	883.8	522.7	4.5	2,190.4
Oklahoma	378.5	.7		559.2	8.3	28.8			.5	151.0	741.1	8.9	13.4	1,890.4
Oregon	235.3			711.5		25.6			14.2	64.2	94.7		4.9	1,150.4
Pennsylvania	156.9						10.6		7.7	98.4	2,026.8	39.5	2.0	2,341.9
Rhode Island							1.8		57.1	48.1	76.8		.9	184.7
South Carolina	43.3	1,202.0		107.7					3.1	186.0	303.7		22.7	1,868.5
South Dakota	204.5	36.0	15.7	3,162.6				9.5			12.9		3.9	3,445.1
Tennessee	104.7			106.3		61.5			361.7	121.6	497.9		7.2	1,260.9
Texas	835.3	39.4		2,857.6	292.2	72.7	119.7	19.8	521.8	709.6	1,307.1	30.2	30.2	6,835.6
Utah	110.9			146.8	3.4	560.9		39.2	.8	10.6	105.9		2.7	981.2

TABLE 28.—*Milcage of Federal-aid roads improved, as of June 30, 1930, by types of construction, by States*—Continued

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bitumi-nous mix	Bitumi-nous macadam	Bitumi-nous concrete	Portland cement concrete	Block	Bridges and ap-proaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Vermont				106.6	2.0	1.2			51.6		89.6		4.6	255.6
Virginia	85.0	216.3		101.3		133.8	9.4		374.1	39.8	502.1		6.1	1,467.9
Washington	179.4			420.4							329.8		5.0	934.6
West Virginia	249.6			28.3		14.2	.6		185.0	28.7	190.2	11.4	2.1	710.1
Wisconsin	144.2	23.8		1,030.2	19.9				13.7	.4	1,007.1		6.9	2,246.2
Wyoming	531.6	10.6		1,060.2				61.9		22.1	15.9		6.4	1,708.7
Hawaii	1.7								6.9	13.3	19.0		.3	41 2
Total	12,448.5	7,166.2	16.5	28,607.9	482.5	1,754.1	603.4	742.0	4,057.1	3,204.7	23,693.3	904.7	331.9	84,012.8

TABLE 29.—*Mileage of Federal-aid roads initially completed during the fiscal year 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bitumi-nous mix	Bitumi-nous macadam	Bitumi-nous concrete	Portland cement concrete	Block	Bridges and ap-proaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama	130.9			20.3						16.9	24.3		1.8	194.2
Arizona	44.4			−8.4				5.9					1.2	43.1
Arkansas	25.7			29.2							44.9		2.8	102.6
California	56.5			73.1				105.2		58.1	40.9		1.8	335.6
Colorado	2.3			56.6				7.9			4.6		.9	72.3
Connecticut									10.8		3.2		.1	14.1
Delaware				11.2				6.8			27.2			45.2
Florida	12.6						16.1			7.1	17.9		.6	54.3
Georgia	17.0	6.8					−3.4		51.3		62.7		.1	134.5
Idaho	3.6			54.7		3.3			15.5					77.1
Illinois	29.8										138.8		.4	169.0
Indiana											214.3		.4	214.7
Iowa				4.9							61.9			66.8
Kansas	282.3	.4		3.5					4.5		28.2	3.2	2.2	324.3
Kentucky	89.6			106.1					12.3		9.8		1.1	218.9
Louisiana	4.5			41.3									.9	46.7
Maine				5.8	21.9				9.6		17.0			54.3
Maryland									23.6		10.5			34.1
Massachusetts									66.2	14.9	8.3		.2	89.6
Michigan	8.0			14.5							148.7		1.2	172.4

Minnesota	224.3				17.7						.3		.2	242.5
Mississippi	55.1			60.1						.5	37.0		2.5	155.2
Missouri	108.3			4.4							102.6		1.7	217.0
Montana	.4			203.5				8.9			.3		1.0	214.1
Nebraska	10.2	120.2									6.9		.5	137.8
Nevada				141.0				6.3						147.3
New Hampshire							.6		1.8		16.6			19.0
New Jersey	2.9			.2			.2		.5	.3	41.0			45.1
New Mexico	39.2			30.4				17.2			.5		.2	87.5
New York	25.5			13.2					40.5		227.6		.1	306.9
North Carolina	4.5	40.2								5.1	40.7		.3	90.8
North Dakota	423.1			119.9	32.5						.8		.9	577.2
Ohio	40.3			1.0			3.3		20.7	1.9	126.6	22.6	1.4	217.8
Oklahoma	46.4									4.9	67.6		.4	119.3
Oregon	65.8			13.1					3.5		4.6		.9	87.9
Pennsylvania	18.6										242.5	13.2		274.3
Rhode Island									12.8	4.1	2.3		.3	19.5
South Carolina	23.7	29.7								1.5	43.6		.4	98.9
South Dakota	65.5	16.7		156.6							3.7		.6	243.1
Tennessee	61.2									5.7	56.2		2.1	125.2
Texas	490.3			3.0	−5.8				−18.8		161.2	1.0	5.1	636.0
Utah	5.8			51.2		10.0					6.4		.3	73.7
Vermont				.4							28.6		.4	29.4
Virginia	32.6	13.1		1.0		22.9	−2.7		47.0	8.4	13.7		1.3	137.3
Washington	34.5			43.7							22.3		.6	101.1
West Virginia	3.1								16.7	5.8	13.1		.3	39.0
Wisconsin	.9			74.4							210.4		2.9	288.6
Wyoming	65.1			52.6				2.2					.5	120.4
Hawaii	1.7													1.7
Total	2,556.2	227.1		1,382.5	66.3	36.2	14.1	160.4	318.5	135.2	2,340.3	40.0	40.6	7,317.4

TABLE 30.—*Mileage of Federal-aid roads under initial construction on June 30, 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama	35.1										47.4		0.7	83.2
Arizona	64.9			25.4				44.1	0.5				1.6	136.5
Arkansas	101.4			10.1						4.3	24.9		2.2	142.9
California	52.2			7.1				15.0	3.8	11.3	28.5		1.5	119.4
Colorado	44.8			84.1				33.1			27.9		3.7	193.6
Connecticut											8.5		2.4	10.9
Delaware				3.3							21.5		.1	24.9
Florida	1.9						12.1	12.1		18.1	50.8		2.1	97.1
Georgia	40.2	9.8					23.6		20.2		24.3		.5	118.6
Idaho	16.3			56.7				11.2					1.0	85.2
Illinois	21.1										425.2	6.2	1.9	454.4
Indiana											152.8		.4	153.2
Iowa											66.0			66.0
Kansas	211.4										34.7		2.6	248.7
Kentucky	94.8			10.6							15.6		.6	121.6
Louisiana	31.4			101.7							16.8		3.9	153.8
Maine				11.8	20.0		2.0		6.3		16.4		1.1	57.6
Maryland											34.3		.5	34.8
Massachusetts									40.9	10.2	14.4		.5	66.0
Michigan	44.6			15.1							167.6		3.3	230.6
Minnesota	171.0			12.1							48.5		.6	232.2
Mississippi	48.4										4.2		2.4	55.0
Missouri	6.5										110.3		.7	117.5
Montana	42.8			387.9				93.3					1.9	525.9
Nebraska	26.2	205.1	22.5							.6	17.6		.9	272.9
Nevada														
New Hampshire			1.5		5.0						30.0		.1	36.6
New Jersey										.3	66.2		.2	66.7
New Mexico				103.1				80.5					1.7	185.3
New York	15.7								47.0	4.1	233.6			300.4
North Carolina	24.6	22.1		28.2				30.1			40.6		1.0	146.6
North Dakota	329.9	.6	3.0	6.7									.3	340.5
Ohio	18.6			21.5		0.1			26.5		221.4	75.3	4.4	367.8
Oklahoma	51.1										64.0		1.3	116.4
Oregon	109.4			38.8	10.8				37.6		5.8		2.1	204.5
Pennsylvania	7.2					12.9					190.6		1.0	211.7
Rhode Island									10.6		16.7		.9	28.2
South Carolina	34.0	21.9									41.3		1.1	98.3

South Dakota	254.4			198.4							.3		1.0	454.1
Tennessee	73.4										58.0		.9	132.3
Texas	236.5			4.7	17.0					17.3	94.0		6.8	376.3
Utah	16.3			36.0			3.4				.5		.1	56.3
Vermont				.5					1.8		39.7		.5	42.5
Virginia	54.2	35.2				96.0			11.2	.9	5.0		.6	203.1
Washington	43.3			34.3		4.3					14.3		.3	96.5
West Virginia	11.8			7.6					22.2		33.0		.4	75.0
Wisconsin	18.4			35.6							141.5		2.1	197.6
Wyoming	123.1			20.7				4.3					.4	148.5
Hawaii									21.4				.1	21.5
Total	2,476.9	294.7	27.0	1,262.0	52.8	113.3	41.1	323.7	250.0	67.1	2,654.7	81.5	64.4	7,709.2

TABLE 31.—*Mileage of Federal-aid roads approved for initial construction on June 30, 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama														
Arizona														
Arkansas	60.6										24.0		1.8	86.4
California	3.5			17.9						9.5	4.8		.4	36.1
Colorado	1.7			16.1				9.9			1.3			29.0
Connecticut									3.0		4.9			7.9
Delaware				3.6					2.4		35.2			41.2
Florida														
Georgia	7.6						14.6				37.3		.1	59.6
Idaho	9.1			45.1									.1	54.3
Illinois	42.9										110.3		.7	153.9
Indiana											9.9			9.9
Iowa											11.8			11.8
Kansas	17.1										3.0		.5	20.6
Kentucky	7.1							14.0		18.1	11.2		.1	50.5
Louisiana				9.7							39.0		.3	49.0
Maine				5.6	8.0				3.6		6.7			23.9
Maryland											25.9		.1	26.0
Massachusetts											10.6		.7	11.3
Michigan	11.1			5.8							13.2			30.1
Minnesota	10.2										9.2			19.4
Mississippi											.1			.1
Missouri											61.6			61.6
Montana	42.0			48.1									.1	90.2
Nebraska		54.6											.1	54.7
Nevada														
New Hampshire														
New Jersey														
New Mexico				32.6										32.6
New York	4.2								16.3	1.1	62.0			83.6
North Carolina		18.0									7.6		.2	25.8
North Dakota	151.2												.1	151.3
Ohio				4.4			3.6		2.5	2.1	52.9	16.5	1.1	83.1
Oklahoma	58.0										33.9		.8	92.7
Oregon	38.6								2.9		6.8		.8	49.1
Pennsylvania	8.4					1.2					72.9	3.7	.9	87.1
Rhode Island														
South Carolina		15.4									11.4		.4	27.2

South Dakota	43.4												.6	44.0
Tennessee	29.9									23.8	28.5		.1	82.3
Texas	99.1									.8			1.7	101.6
Utah				44.9										44.9
Vermont											5.7			5.7
Virginia	7.7	6.3				12.4					1.2		.4	28.0
Washington	1.2			.6									.3	2.1
West Virginia	14.0								.6		5.9			20.5
Wisconsin											27.9		.1	28.0
Wyoming	13.6												.1	13.7
Hawaii									9.0				.2	9.2
Total	682.2	94.3		234.4	8.0	13.6	18.2	23.9	40.3	55.4	736.7	20.2	12.8	1,940.0

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TABLE 32.—*Mileage of Federal-aid stage construction completed during the fiscal year 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama											14.5			14.5
Arizona	9.6			0.6				36.3					0.1	46.6
Arkansas											14.0		.3	14.3
California	9.4			1.0							9.3		.3	20.0
Colorado								34.5			2.4		1.2	38.1
Georgia				7.8			3.8		15.2		14.6			41.4
Iowa				15.2							131.4			146.6
Kansas											16.9			16.9
Kentucky				35.3										35.3
Maryland											14.7			14.7
Massachusetts											.1		.6	.7
Michigan											2.9			2.9
Minnesota	11.2										71.6			82.8
Mississippi				3.2							1.0		.2	4.4
Missouri	10.8										127.6		.4	138.8
Montana				3.9									.2	4.1
Nebraska		154.2	0.8		−0.9					0.4	6.8		.1	161.4
Nevada				16.8				174.9					.2	191.9
New Hampshire											1.0			1.0
New Mexico											.7			.7
North Carolina		1.1									8.3		.1	9.5
North Dakota				344.1	48.0						.4			392.5
Oklahoma											−.1	59.1	.1	59.1
South Carolina											22.3	22.7		45.0
South Dakota	3.0			31.7				5.5			2.0			42.2
Texas	6.1								81.4	17.5	262.4		.7	368.1
Virginia										14.8	6.8		.1	21.7
Washington				10.4										10.4
West Virginia						9.9					7.7			17.6
Wisconsin											31.1		.6	31.7
Wyoming				19.0				17.2					.1	36.3
Total	50.1	155.3	.8	489.0	47.1	9.9	3.8	268.4	96.6	54.9	830.0		5.3	2,011.2

TABLE 33.—*Mileage of Federal-aid roads under stage construction on June 30, 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama											22.0		0.2	22.2
Arizona	39.7							109.0					.4	149.1
Arkansas				7.5							38.5		.2	46.2
California	7.9			5.3							13.9		.7	27.8
Colorado				2.2				9.3			16.4		.4	28.3
Florida							5.4						.1	5.5
Georgia							2.8			16.0	13.4			32.2
Idaho				27.8										27.8
Iowa											176.9			176.9
Kansas	1.5										26.3			27.8
Kentucky											5.4		.1	5.5
Louisiana											14.2		.1	14.3
Maryland											6.7			6.7
Michigan											30.4			30.4
Minnesota	51.3									.1	186.0		.1	237.5
Mississippi	7.6												.1	7.7
Missouri											61.2		.1	61.3
Montana				.8				42.8					.1	43.7
Nebraska	.3	30.0									115.0		.6	145.9
Nevada								122.1						122.1
New Mexico				17.8				31.4					1.5	50.7
North Carolina	13.5			6.8							8.5		.1	28.9
North Dakota	24.3			79.6	23.9									127.8
Ohio											25.6	8.5	1.1	35.2
Oklahoma											47.7			47.7
Oregon	1.2			6.6					77.5				.1	85.4
Pennsylvania											14.1			14.1
South Carolina											80.3			80.3
South Dakota	19.9			101.6							20.4		.1	142.0
Tennessee											12.5			12.5
Texas					7.6				13.1		98.8		.3	119.8
Utah				7.8				2.8			.2			10.8
Vermont											1.2			1.2
Virginia						0.8			9.8		2.2		.8	13.6
Washington	18.1			11.7										29.8
West Virginia						5.4					22.4			27.8
Wisconsin											48.1			48.1
Wyoming	.8			37.8				53.7					.3	92.6
Total	186.1	30.0		313.3	31.5	6.2	8.2	371.1	100.4	16.1	1,108.3	8.5	7.5	2,187.2

TABLE 34.—*Mileage of Federal-aid road approved for stage construction on June 30, 1930, by types of construction, by States*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Arizona								15.8						15.8
Arkansas	3.5													3.5
California											2.1			2.1
Colorado				6.4				62.6						69.0
Georgia							14.7				53.6		0.1	68.4
Idaho				3.5				33.6			5.3			42.4
Illinois											63.5			63.5
Iowa											27.8			27.8
Kansas	.1	47.5		35.7							6.0		.2	89.5
Kentucky				27.6				155.8	1.7	3.4	40.1		.1	228.7
Louisiana											11.3		.1	11.4
Minnesota											32.3			32.3
Missouri											27.7			27.7
Montana				11.5				29.2						40.7
Nebraska		69.3									21.7		.1	91.1
Nevada								81.0						81.0
New Mexico											1.9			1.9
North Carolina										1.9				1.9
North Dakota	7.9			174.7	9.0			15.5						207.1
Ohio											12.9		.2	13.1
Oklahoma	2.6										47.0		.1	49.7
South Carolina											26.2			26.2
South Dakota	17.9			52.7										70.6
Tennessee											38.2			38.2
Texas											52.7			52.7
Utah								78.8						78.8
Washington				6.5										6.5
West Virginia	7.8								1.8		7.6			17.2
Wyoming				22.8				40.4						63.2
Total	39.8	116.8		341.4	9.0		14.7	512.7	3.5	5.3	477.9		.9	1,522.0

TABLE 35.—*Net changes in the types of Federal-aid improvements on the Federal-aid highway system during fiscal year 1930*

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
Alabama	116.7			19.0						16.9	38.7		1.8	193.1
Arizona	49.5	−0.5		−168.8				42.2					1.6	−76.0
Arkansas	21.9			−46.8		−5.4	−32.3				58.9		2.9	−.8
California	52.6			62.8				105.9	−0.8	58.1	37.1		1.9	317.6
Colorado	−10.1			29.3				42.4			6.9		1.9	70.4
Connecticut						−.2			11.0		3.1		.1	14.0
Delaware				11.2				6.7			27.3		.1	45.3
Florida	12.4	.3					16.1			7.2	17.9		.6	54.5
Georgia	−7.7	−4.9		7.0	3.7		−3.5		66.5		77.4		.1	138.6
Idaho	−20.5			50.9		3.3	−28.5	28.5	15.6				.1	49.4
Illinois	29.8										138.8		.4	169.0
Indiana											214.2		.5	214.7
Iowa	−137.3			−79.4							187.2		.2	−29.3
Kansas	241.6	−4.1		3.5					4.4		44.0	2.6	2.4	294.4
Kentucky	57.6			135.9					12.3		9.9		1.0	216.7
Louisiana	4.4			27.1									.8	32.3
Maine				5.9	21.8				7.6		19.0			51.3
Maryland									20.6		.9			21.5
Massachusetts									63.0	12.3	11.0		.1	86.4
Michigan	8.0			−15.7							151.6		1.2	145.1
Minnesota	152.2			−173.2	17.6						71.9		.3	68.8
Mississippi	60.5			63.0						.5	38.0		2.6	164.6
Missouri	4.1			−23.0					.5		225.4		2.0	209.0
Montana	.4			167.7				8.8			.4		1.2	178.5
Nebraska	−96.3	132.6								.4	13.6		.4	50.7
Nevada	−13.5			−31.3				181.2			1.0		.1	137.5
New Hampshire						.1	.5		2.4	−2.7	19.7			20.0
New Jersey	2.9			.2			.2		.5	.3	41.0			45.1
New Mexico	39.2			−20.5				17.2			1.2		−.4	36.7
New York	25.5			13.2					40.5		227.5		.1	306.8
North Carolina	−15.9	30.2		−.7						5.1	48.9		.5	68.1
North Dakota	38.8	−5.2		469.1	80.6						1.2		.9	585.4
Ohio	26.8			1.0			3.3		15.7	−7.5	125.2	21.5	1.4	187.4
Oklahoma	−21.0			−15.9						−3.0	111.3		.3	68.7
Oregon	65.8			−72.3					3.5		4.6		.8	2.4
Pennsylvania	18.6					−10.6	10.6			−2.3	242.6	13.1	.1	272.1
Rhode Island									12.8	4.1	2.4		.2	19.5
South Carolina	15.2	−52.9								23.8	66.2		.5	52.8

TABLE 35.—*Net changes in the types of Federal-aid improvements on the Federal-aid highway system during fiscal year 1930*—Continued

State	Graded and drained	Sand-clay		Gravel		Macadam		Low-cost bituminous mix	Bituminous macadam	Bituminous concrete	Portland cement concrete	Block	Bridges and approaches	Total
		Untreated	Treated	Untreated	Treated	Untreated	Treated							
South Dakota	−37.0	16.7		142.3				5.5			5.7		0.6	133.8
Tennessee	48.1									5.7	56.1		2.6	112.5
Texas	269.3	8.4		−13.8	−5.9				62.7	17.5	423.7	1.0	5.5	768.4
Utah	5.8			51.1		−0.7				.1	6.4		.3	63.0
Vermont				−2.3		−.2					28.6		.4	26.5
Virginia	32.3	10.4		1.0		10.9	−2.7		31.9	23.2	15.1		.5	122.6
Washington	24.1			54.1							22.3		.6	101.1
West Virginia	−24.5					9.9			14.5	5.8	20.8		.2	26.7
Wisconsin	−15.8	−9.9		−3.1							216.7		3.5	191.4
Wyoming	17.5	−4.0		12.5				9.4					.6	36.0
Hawaii	1.7													1.7
Total	1,040.7	117.1		661.0	117.8	7.1	−36.3	447.8	385.2	165.5	3,081.4	38.2	43.5	6,069.0

TABLE 36.—*Federal-aid apportionment, and amounts paid to the States for the fiscal year 1930, and the unobligated balance of the total apportionment on June 30, 1930*

State	Apportionment fiscal year 1930	Paid to States during the fiscal year 1930	Unobligated balances of total apportionment on June 30, 1930
Alabama	$1,554,221.00	$1,092,685.93	$4,083,610.18
Arizona	1,061,111.00	1,560,058.27	1,898,927.83
Arkansas	1,284,382.00	650,764.79	1,518,012.42
California	2,495,345.00	3,931,822.91	1,743,512.14
Colorado	1,388,755.00	1,402,520.46	2,283,553.54
Connecticut	477,110.00	281,922.76	714,247.71
Delaware	365,625.00	594,597.88	91,051.91
Florida	909,235.00	660,158.48	1,681,203.79
Georgia	1,980,443.00	623,085.28	2,902,272.18
Idaho	933,902.00	574,315.68	1,175,024.06
Illinois	3,118,949.00	1,908,477.62	4,656,255.25
Indiana	1,917,036.00	2,295,345.32	2,473,551.58
Iowa	2,020,861.00	2,504,338.70	1,892.77
Kansas	2,058,305.00	2,541,954.83	2,063,112.86
Kentucky	1,417,634.00	1,537,194.33	114,878.62
Louisiana	1,026,696.00	852,639.40	1,224,288.48
Maine	678,501.00	1,187,526.36	1,354,501.03
Maryland	633,615.00	466,652.87	5,543.03
Massachusetts	1,090,077.00	1,546,517.25	1,944,255.39
Michigan	2,204,966.00	2,300,913.73	2,782,145.14
Minnesota	2,108,104.00	2,192,899.80	46,352.03
Mississippi	1,311,391.00	745,258.17	3,527,955.68
Missouri	2,392,021.00	3,436,554.13	831,704.84
Montana	1,554,060.00	2,571,899.09	3,540,456.15
Nebraska	1,586,299.00	1,980,717.15	2,176,337.14
Nevada	960,375.00	996,033.53	773,969.02
New Hampshire	365,625.00	464,211.66	221,369.45
New Jersey	937,434.00	629,055.00	977,248.76
New Mexico	1,189,085.00	827,764.88	969,531.76
New York	3,617,748.00	4,078,108.85	7,315,347.86
North Carolina	1,716,919.00	711,610.60	2,560,469.31
North Dakota	1,197,586.00	1,236,250.08	1,452,524.56
Ohio	2,754,446.00	2,455,602.56	939,205.53
Oklahoma	1,748,857.00	2,080,335.52	184,302.92
Oregon	1,191,989.00	703,274.47	288,573.31
Pennsylvania	3,325,854.00	3,710,013.31	1,082,376.94
Rhode Island	365,625.00	171,477.02	588,570.42
South Carolina	1,061,447.00	926,038.22	97,283.99
South Dakota	1,229,282.00	1,162,383.12	1,062,892.43
Tennessee	1,609,662.00	1,459,546.34	1,552,381.84
Texas	4,531,162.00	6,292,484.66	4,647,819.57
Utah	848,592.00	730,519.47	662,833.17
Vermont	365,625.00	366,821.03	
Virginia	1,433,405.00	1,090,622.55	691,693.83
Washington	1,149,489.00	1,377,438.14	1,211,773.29
West Virginia	796,408.00	874,504.14	628,588.82
Wisconsin	1,854,580.00	3,058,505.08	816,349.40
Wyoming	939,536.00	958,322.93	588,414.28
Hawaii	365,625.00	79,118.49	1,568,624.59
Total	73,125,000.00	75,880,862.84	75,716,790.80

NATIONAL-FOREST ROAD CONSTRUCTION

During the past year improvements have been completed on 266.8 miles of the forest-road system, bringing the total mileage improved to date with Federal funds to 4,357.5 miles. Of the mileage improved during the year, 244.7 miles were in the Western States and Alaska, and the remaining 22.1 miles were in the forests of four Eastern States. Of the total mileage improved to date, 4,026.7 miles are in the West and 330.8 in the East.

The mileage of forest-highway projects completed during the year and to date by States is shown in Table 37.

TABLE 37.—*Mileage of completed forest-highway projects, by States*

State	Mileage of forest-highway projects completed—		State	Mileage of forest-highway projects completed—	
	During 1930	Total to June 30, 1930		During 1930	Total to June 30, 1930
Western:			Eastern:		
Alaska	17.5	222.0	Alabama		5.1
Arizona	28.3	336.2	Arkansas	5.4	65.2
California	66.9	383.7	Florida		64.2
Colorado	13.6	345.7	Georgia		21.4
Idaho	24.1	508.4	Michigan		8.1
Montana	24.5	391.7	Minnesota	11.7	60.6
Nevada	3.6	114.5	New Hampshire	1.6	5.2
New Mexico	2.2	190.4	North Carolina		36.3
Oregon	30.4	677.5	South Carolina		16.0
South Dakota		46.2	Tennessee		33.5
Utah	7.0	307.9	Virginia	3.4	15.2
Washington	11.9	227.7			
Wyoming	14.7	274.8	Total	22.1	330.8
Total	244.7	4,026.7	Grand total	266.8	4,357.5

In the forest-highway system as approved to date there are 14,576.1 miles, of which 12,378.8 miles are in the Western States and Alaska and 2,197.3 miles are in the Eastern States. Class 1 highways, which are necessary sections or extensions of the Federal-aid highway system lying wholly within the forest areas, total 1,316.1 miles, of which 924.1 miles are in the Western States. Class 2 highways, which also extend the Federal-aid system, total 7,293.4 miles, of which 6,961.8 are in the West. The class 3 highways, those that serve communities within the forests, total 5,966.6 miles, of which 4,492.9 miles are in the Western States.

The mileage of each of the three classes of highways and the total mileage of the forest-highway system in each State are shown in Table 38.

TABLE 38.—*Classified mileage of forest-highway system, by States*

State	Mileage of forest-highway system: Class 1	Class 2	Class 3	Total
Western:				
Alaska			415.1	415.1
Arizona	263.3	491.0	255.0	1,009.3
California	321.5	991.0	926.3	2,238.8
Colorado		1,240.0	483.0	1,723.0
Idaho	4.0	760.7	328.5	1,093.2
Montana	147.4	657.2	381.0	1,185.6
Nevada		373.8	97.0	470.8
New Mexico	115.0	211.0	199.0	525.0
Oregon	66.2	782.4	591.2	1,439.8
South Dakota	2.0	169.0	63.0	234.0
Utah		457.9	290.2	748.1
Washington	4.7	472.8	311.6	789.1
Wyoming		355.0	152.0	507.0
Total	924.1	6,961.8	4,492.9	12,378.8
Eastern:				
Alabama			41.0	41.0
Arkansas	169.8	34.0	14.0	217.8
Florida		0.7	106.0	106.7
Georgia			99.0	99.0
Maine			11.0	11.0
Michigan		13.4	53.0	66.4
Minnesota	41.0	38.5	166.0	245.5
Nebraska			28.8	28.8
New Hampshire	30.0	50.0	49.0	129.0
North Carolina	78.7	50.0	108.9	237.6
Oklahoma			33.0	33.0
Pennsylvania	24.5	16.0	157.0	197.5
South Carolina		6.0	40.0	46.0
Tennessee	48.0	81.0	167.0	296.0
Virginia		38.0	269.0	307.0
West Virginia		4.0	131.0	135.0
Total	392.0	331.6	1,473.7	2,197.3
Grand total	1,316.1	7,293.4	5,966.6	14,576.1

Progress in improvement of the system, which has been maintained at about the present rate for several years, will now be accelerated as a result of the increased funds authorized for appropriation for the fiscal years 1931, 1932, and 1933. For these three years the total forest-road appropriation authorized is $12,500,000 (includes $3,000,000 for forest development roads not necessarily on the system) instead of the $7,500,000 which has been authorized for several years past.

The demand for a higher type of construction on forest highways, especially those of classes 1 and 2, which are included in the Federal-aid and State systems, is evidenced by the fact that a number of projects recently graded and surfaced by the bureau with fine crushed rock have been immediately oiled by the State highway departments, notably in California and Oregon.

The proportion of mileage surfaced by the bureau is increasing, and it is generally expected that the surfaces will be oiled shortly after completion. The low-cost surface treatment provides a surface which, so far as the comfort of the traveling public is concerned, usually equals hard surfaces of higher type, and it also reduces wear and tear of vehicles. The cost of the treatment is offset in a few years by the reduction in maintenance cost.

Encouraging progress is being made in the construction of forest routes which serve as approaches to the national parks. Construction is nearing completion on the Grand Canyon–Old Trails route

in Arizona, which is the south approach to the Grand Canyon National Park. Similar progress has been made in the construction of the south approach to Lassen Volcanic Park; and the reconstruction of the West Gallatin entrance to the Yellowstone is also approaching completion.

The Gardiner Bridge on the Yellowstone Canyon entrance to Yellowstone Park, which was put under construction during the year, will be opened shortly, and its completion will fill the last gap in the forest-highway approach to the park.

The Columbia Falls-Glacier Park Highway in Montana will be completed this year. This route is of the highest importance to the Glacier National Park and State and interstate traffic. It has been under construction for the past 10 years, and because of the rugged country it traverses the construction has been rather expensive.

Another park-approach road on which very satisfactory progress has been made is the Randle-Yakima Highway in Washington. This route serves Mount Rainier National Park in the same way that the Columbia Falls-Glacier Park route serves Glacier Park.

ROAD CONSTRUCTION IN THE NATIONAL PARKS

Steady progress has been made during the year on the construction of highways in the national parks. This work is supervised by the bureau under an agreement with the National Park Service of the Department of the Interior. The year's work brought to completion 88.7 miles, making the total mileage thus far improved 302.1 miles, all of which is in the system of major park roads which has been designated, including a total of 1,509.7 miles.

At the end of the year construction was in progress on 67.3 miles, of which 20 miles was stage construction.

The mileage included in the designated system in the several parks and the record of completion during the last year and to date are shown in Table 39.

The road construction in the national parks involves some of the most interesting work of the bureau. It is necessarily expensive because of the very rugged country in which it is done and the care that must be observed to avoid marring the landscape.

TABLE 39.—*The program of national-park road improvement, and the mileage of roads improved under the supervision of the Bureau of Public Roads*

National park	Mileage of the program	Mileage completed under the supervision of the bureau		National park	Mileage of the program	Mileage completed under the supervision of the bureau	
		During the fiscal year 1930	Total to June 30, 1930			During the fiscal year 1930	Total to June 30, 1930
Crater Lake	70.5	1.9	23.3	Yellowstone	369.2	3.5	23.9
Glacier	145.9	2.3	32.5	Zion	22.4	4.1	8.7
Mount Rainier	122.1	27.7	41.7	Hawaii	83.6	-------	11.2
Grand Canyon	156.7	25.6	59.5	Mesa Verde	47.3	6.0	6.0
Yosemite	218.6	8.6	36.5	Acadia	4.5	-------	-------
Sequoia	84.5	2.0	25.2	Wind Cave	5.4	4.3	4.3
General Grant	-------	-------	4.0	Mount McKinley	73.5	-------	-------
Lassen Volcanic	39.5	2.7	16.3				
Rocky Mountain	64.4	-------	8.7	Total	1,509.7	88.7	302.1
Devil's Tower National Monument	1.6	-------	0.3				

All park roads serve a heavy traffic during the season, especially on important holidays when the number of vehicles using them amounts to many thousands daily. To eliminate dust and provide adequately for the comfort of those who visit the parks for pleasure and recreation it is necessary that the surface of all roads built be treated with bituminous material as promptly as possible after they are graded. Eventually, it is anticipated that a high type of surface will be needed on all park roads.. Until such a surface can be constructed, surfaces of selected local material, oil treated, are the lowest type that can be considered.

The road in Zion Park, recently completed, was dedicated on July 4, 1930. This road, on which there is more than a mile of tunnel with galleries opening through the wall of Pine Creek Canyon, is already one of the country's most famous highways, although few people have yet had an opportunity to see it.

Another road on which there will be a long tunnel—about 4,200 feet in length—is being planned for construction at an early date in Yosemite National Park. The fact that such tunnels are necessary gives some idea of the extreme difficulties of road location in the rugged and almost inaccessible regions now, for the first time, to be brought within the reach of the ordinary traveler.

Of outstanding interest among the projects completed during the past year are the roads to the north rim of the Grand Canyon at Bright Angel Point and Cape Royal. The construction of these roads involved over 25 miles of heavy grading. In Mount Ranier National Park the Paradise section of the Nisqually Road, 8.5 miles long, and the White River Road, nearly 5 miles in length, have also been completed. The former is the southwest entrance to the park and the latter is the approach from the northwest. Both were very heavy pieces of construction. In the Yellowstone, the East Entrance-Sylvan Pass Road has been completed, a road 3.5 miles long. These roads are important as the means of developing and giving access to points of great beauty in the hitherto isolated portions of these great national playgrounds.

Not the least of the interesting features of the national-park roads are their bridges, all of which are designed to harmonize with the natural surroundings.

The Happy Isles bridge in Yosemite National Park was completed during the past year. This bridge—the sixth major structure built by the bureau—is a strikingly beautiful stone-faced concrete arch. The Swift Current Creek bridge on the Babb-Many Glacier route is another important structure completed during the year. Because of the unsatisfactory bids received for this bridge, construction was undertaken by the day-labor method under the bureau's supervision, and the work was completed, in spite of severe weather conditions and other difficulties, by the opening of the park season this year.

The designs of these bridges and, in fact, all of the work done on the national-park roads, are subject to the approval of the Park Service, which is at all times alert to preserve and develop the natural beauty of the extraordinary regions in which they are built.

RESTORATION OF FLOOD-DAMAGED ROADS

By several acts since 1928 Congress has authorized and made appropriations for the relief of a number of States as a reimbursement or contribution in aid from the United States, induced by the extraordinary conditions of necessity and emergency resulting from the unusually serious financial losses to such States through damage to or destruction of roads and bridges by floods in 1927 and 1929.

The first of these acts—that approved May 16, 1928—appropriated a total sum of $5,197,294 in three parts, as follows: For the State of Vermont, $2,654,000; for New Hampshire, $653,300; for Kentucky, $1,889,994. These appropriations were made available for expenditure by the State highway departments, with the approval of the Secretary of Agriculture, for the restoration and relocation of roads and bridges damaged or destroyed when the State has made available a like sum from State funds for the purpose. In these States the Federal appropriation is expendable only upon work undertaken with the approval of the Secretary of Agriculture after the passage of the act.

The acts since passed providing for similar relief of other States permit the expenditure of the sums appropriated either to reimburse the States for a portion of expenditures made before the passage of the acts or to assist them in work subsequently undertaken with the approval of the Secretary of Agriculture. In every case it is necessary that the State shall have expended or made available for expenditure State funds in an amount equal to the Federal reimbursement or contribution.

The several acts making such provision, the States benefited, and the amount of the Federal appropriation for each are as follows:

The act approved February 28, 1929, appropriated for reimbursement or aid to the State of Missouri, $258,418; to Mississippi, $628,000; to Louisiana, $967,582; and to Arkansas, $1,800,000.

The act approved March 26, 1930, appropriated for reimbursement or aid to Alabama the sum of $1,660,000 previously authorized, less 2½ per cent for Federal administration.

The act approved July 3, 1930, appropriated for reimbursement or aid to the States of Georgia and South Carolina the amounts previously authorized as follows: Georgia, $506,067.50; South Carolina, $805,561; in each case less 2½ per cent for Federal administration.

As required by these acts, rules, and regulations for carrying out their purposes have been promulgated by the Secretary of Agriculture.

The amounts of the several appropriations (less the 2½ per cent allowed for Federal administration in the case of Alabama, Georgia, and South Carolina), the amounts paid to the States up to June 30, 1930, and the unobligated balance for each State are shown in Table 40. The amounts paid during the past fiscal year are reported in Table 41.

The mileage of road improved during the fiscal year and the corresponding total cost and Federal payment are given in Table 42; and similar information with reference to all improvements completed up to June 30 is given in Table 43, while Tables 44 and 45 give similar data with respect to the flood-relief roads under construction and approved for construction on June 30, 1930.

TABLE 40.—*Flood relief appropriated, amounts paid to States, and the unobligated balance of the appropriation on June 30, 1930*

State	Appropriated	Paid to the States to June 30, 1930	Unobligated balance
Vermont	$2,654,000.00	$2,490,742.00	$33,376.39
New Hampshire	653,300.00	563,345.89	45,301.04
Kentucky	1,889,994.00	393,595.65	1,327,384.62
Total	5,197,294.00	3,447,683.54	1,406,062.05
Arkansas	1,800,000.00		1,719,403.62
Louisiana	967,582.00		967,582.00
Mississippi	628,000.00	341,702.91	282,582.61
Missouri	258,418.00		258,418.00
Total	3,654,000.00	341,702.91	3,227,986.23
Alabama	1,618,500.00		1,337,716.29
Georgia	493,416.00		493,415.81
South Carolina	785,422.00		785,421.98
Total	2,897,338.00		2,616,554.08
Grand total	1,748,632.		7,250,602.36

TABLE 41.—*Flood relief paid to the States during the fiscal year 1930*

Vermont	$836,095.47
New Hampshire	456,203.99
Kentucky	238,259.12
Total	1,530,558.58
Mississippi	341,702.91
Grand total	1,872,261.49

TABLE 42.—*Total cost, flood relief, and mileage of roads improved during the fiscal year 1930*

State	Total cost	Flood relief	Mileage
Vermont	$3,765,044.36	$1,634,157.61	36.7
New Hampshire	592,130.03	291,976.21	16.9
Kentucky	706,684.22	325,200.44	39.0
Total	5,063,858.61	2,251,334.26	92.6
Mississippi	7,428.96	[1] 345,417.39	.3
Total	5,071,287.57	2,596,751.65	92.9

[1] $341,702.91 represents a reimbursement to the State for work completed prior to the flood relief act.

TABLE 43.—*Total cost, flood relief, and mileage of roads improved to June 30, 1930*

State	Total cost	Flood relief	Mileage
Vermont	$5,507,928.24	$2,492,941.31	57.8
New Hampshire	1,224,175.61	607,998.96	24.6
Kentucky	706,684.22	325,200.44	39.0
Total	7,438,788.07	3,426,140.71	121.4
Mississippi	7,428.96	[1] 345,417.39	.3
Total	7,446,217.03	3,771,558.10	121.7

[1] $341,702.91 represents a reimbursement to the State for work completed prior to the Flood Relief Act.

TABLE 44.—*Total cost, flood relief, and mileage of roads under construction on June 30, 1930*

State	Total cost	Flood relief	Mileage
Vermont	$299,826.60	$127,682.30	3.5
New Hampshire			
Kentucky	322,512.35	155,655.44	18.5
Total	622,338.95	283,337.74	22.0

TABLE 45.—*Total cost, flood relief, and mileage of roads approved for construction on June 30, 1930*

State	Total cost	Flood relief	Mileage
Kentucky	$194,267.73	$81,753.50	10.8
Arkansas	3,854.29	1,927.14	
Total	198,122.02	83,680.64	10.8

The mileage of the several types of flood-relief roads completed in the several States during the fiscal year 1930 is given in Table 46; and the total mileage completed, under construction, and approved for construction on June 30, 1930, classified by types and by States, is given in Table 47.

TABLE 46.—*Mileage of the various types of flood-relief roads completed during the fiscal year 1930*

Type of construction	Vermont	New Hampshire	Kentucky	Mississippi	Total
Graded and drained			38.8		38.8
Gravel, untreated	2.4				2.4
Gravel, treated	9.1	2.2			11.3
Macadam, treated		2.7			2.7
Bituminous macadam	3.6				3.6
Portland cement concrete	17.5	12.0		0.3	29.8
Bridges	4.1		.2		4.3
Total	36.7	16.9	39.0	.3	92.9

TABLE 47.—*Mileage of the various types of flood-relief roads completed, under construction, and approved for construction, June 30, 1930, in Vermont, New Hampshire, Kentucky, and Mississippi*

Type of construction	Vermont		New Hampshire (completed)	Kentucky			Mississippi (completed)
	Under construction	Completed		Approved for construction	Under construction	Completed	
Graded and drained				10.6	18.4	38.8	
Gravel, untreated	0.8	6.3					
Gravel, treated		9.1	5.1				
Macadam, treated			2.7				
Bituminous macadam	2.6	3.6	2.3				
Portland cement concrete		32.6	13.9				0.3
Bridges	.1	6.2	.6	.2	.1	.2	
Total	3.5	57.8	24.6	10.8	18.5	39.0	.3

MOUNT VERNON MEMORIAL HIGHWAY

Construction work on the Mount Vernon Memorial Highway was begun in September, 1929, under a contract for the placing of a riprap sea wall to protect the section of the highway to be built on made land in the old bed of the Potomac River from Columbia Island to the railroad bridge, the construction of a cofferdam, and the supply of stone for bridge facing, at the price of $96,610.

Provision for the construction of this highway from Washington to Mount Vernon as a memorial to George Washington was made by the act of Congress, approved May 23, 1928, which authorized the United States Commission for the Celebration of the Two Hundredth Anniversary of the Birth of George Washington to survey, select, construct, and maintain the road, in cooperation with the Secretary of Agriculture.

At the request of the commission surveys of two alternate routes were made by this bureau during the fiscal year 1929, and on January 24, 1929, the commission selected the location known as the river route, which extends from the Arlington Memorial Bridge at Columbia Island along and close to the Virginia shore of the Potomac, a distance of 15½ miles to the Mount Vernon estate.

The preparation of detailed plans for the construction was well advanced at the beginning of the fiscal year 1930, and during the year all plans for grading and incidental drainage structures, for the major bridges, and other features necessary for the rapid prosecution of the work have been completed.

The beginning of the first work, mentioned above, was followed shortly by the negotiation of an agreement with the Corps of Engineers, United States Army, under which that branch of the military service undertook to construct approximately 2¼ miles of hydraulic fill in five sections at actual cost which is estimated as $900,000. Rapid progress has been made in this phase of the construction, and at the close of the year four of the five fills had been completed, and the fifth was under construction. Great credit is due the Corps of Engineers for the celerity and high efficiency with which this work has been performed and the excellence of the resulting fills.

The contract for approximately 12½ miles of dry-land grading and small drainage structures and incidental construction was awarded in March, 1930, at a price of $435,890.60, and at the close of the fiscal year this work was making very satisfactory progress.

Work on the construction of the major bridges, of which there are 12, including the important highway grade-crossing elimination structure at the south end of the existing Potomac River highway bridge, was begun under a contract awarded in April, 1930, calling for the erection of these structures at a cost of $1,777,027. At the end of the fiscal year work had been begun and was well advanced on several of these structures.

The paving of the road, which will follow the completion of the grading as closely as the time necessary for the settlement of the fills will permit, will be undertaken under another contract to be advertised shortly after January 1, 1931, and it now appears to be reasonably assured that the road will be ready for opening in connection with the celebration of the bicentennial in 1932.

The road as planned will have a minimum pavement width of 40 feet on a minimum right of way of 200 feet except through the city of Alexandria, Va.

Special attention has been given to the development of interesting alignment, and the long, easy curves, fitted to the natural contour of the land, are outstanding features of the design. With the aid of a landscaping scheme which has been carefully studied the road will appear when completed as a natural part of the countryside. The scars of construction, which detract from the pleasure of driving over many new roads, will be carefully obliterated on this highway.

All important crossroads will be carried under or over the highway on grade-separating bridges, and minor roads intersecting at grade will enter the highway from the two sides at points separated by a considerable distance so as to avoid direct crossing of the principal line of traffic.

Features of the plan which are of more than usual interest are the "clover-leaf" highway grade separation structure at the south end of the existing highway bridge over the Potomac at Washington; the large terminal circle and concealed parking areas at Mount Vernon; and the flared and divided roadways which at suitable points have been provided to facilitate turning and halting of vehicles to permit visitors to enjoy views of the river and distant Washington.

INTER-AMERICAN HIGHWAY

The Sixth International Conference of American States, held at Habana, Cuba, recommended, by resolution, to the Pan American Congress of Highways, which met at Rio de Janeiro in August, 1929, the consideration and adoption of agreements looking to the construction of a Pan American highway connecting North America, Central America, and South America.

By joint resolution, approved May 4, 1928, the United States Congress, taking cognizance of the above-mentioned resolution, requested the President to direct the several agencies of the Government to lend such cooperation and assistance as might be feasible and appropriate with a view to having the matter of the proposed highway thoroughly considered by the approaching Pan American Congress.

By another joint resolution, approved March 4, 1929, Congress authorized the appropriation of $50,000 to enable the Secretary of State to cooperate with the several Governments members of the Pan American Union in reconnaissance surveys to develop the facts, and to report to Congress as to the feasibility of possible routes, the probable cost, the economic service, and such other information as would be pertinent to the building of an inter-American highway or highways.

At the Pan American Congress of Highways, to which the question had been referred for consideration, the United States was represented by an official delegation, which joined with the delegates of other American States represented in commending to the several Governments the importance of suitable international highway connections.

Following the Congress at Rio de Janeiro, the United States was also represented by a delegation appointed by the Secretary of State

at an inter-American highway conference called by the Government of the Republic of Panama which met at Panama from October 7 to 12, 1929. At this conference a resolution was adopted recommending the creation of an inter-American highway commission to carry on the work of determining the most feasible route of an inter-American highway, and to take such other steps and make such recommendations as will contribute to the realization of the project.

In accordance with the terms of this resolution, the Governments of Costa Rica, Guatemala, Panama, and Salvador have designated representatives on the proposed commission; but the Government of the United States has not yet complied.

However, the Governments of Guatemala and Nicaragua have expressed through the Director of the Pan American Union and the diplomatic missions of the United States a desire to have a reconnaissance survey undertaken to determine the most desirable route for an inter-American highway across their respective territories, and have thus complied fully with the conditions of the joint resolution authorizing an appropriation to enable the United States to cooperate in such an undertaking.

Accordingly, the authorized appropriation was made by act of Congress approved March 26, 1930, and the Secretary of State has designated, with the approval of the President, a technical committee consisting of three engineers of this bureau to cooperate with the Governments of Guatemala and Nicaragua in the surveys requested and with such other Governments members of the Pan American Union from which similar requests may be received.

Late in June, 1930, the members of this committee sailed for Panama, where headquarters have been provided through the courtesy of the Panamanian Government; and the requested surveys in Nicaragua and Guatemala will be undertaken at once under the immediate direction of this bureau in compliance with the orders of the Secretary of State.

SIXTH INTERNATIONAL ROAD CONGRESS

At the invitation of the United States Government, the Sixth International Road Congress will be held in Washington from October 6 to 11, 1930. The congress will be the sixth meeting of the Permanent International Association of Road Congresses, an association in which the United States holds membership as a contributing Government.

Appropriations amounting to $55,000 have been made by Congress to defray the expense of the Washington sessions, and the Secretary of State has appointed an American organizing commission to make the necessary arrangement.

During the past fiscal year this bureau has cooperated with the commission appointed in every proper way in order to assure the success of the congress, which is expected to bring to the United States a large number of highway engineers of foreign countries for a discussion of road problems of mutual interest and concern to all countries.

HIGHWAY-TRANSPORTATION INVESTIGATIONS

WESTERN STATES TRAFFIC SURVEY

The survey of traffic on the Federal-aid highway system in 11 western States, to which reference was made in the last annual report, was begun in most of the States in September, 1929. In a few the counts were not begun until October. It will be continued in all of the States for a complete year.

The States in which the counts are being made are Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Wyoming, Colorado, New Mexico, and Nebraska. In each State the work is being done in cooperation with the State highway department.

The results of this survey, when analyzed, compiled, and mapped, will provide accurate information with regard to the flow of traffic on the main roads of nearly the entire western half of the United States. As such information forms the essential basis of a thoroughly national plan of highway improvement it will be an invaluable guide in the administration of Federal-aid road construction in the future. No such completely coordinated information with respect to the traffic in such a broad area has been available previously in any part of the United States, and it is hoped that the demonstration of the practicability of obtaining it and its usefulness as an aid in the determination of the type and character of future road improvements will lead to the formulation of a plan by which similar data may be obtained and annually revised throughout the United States.

In addition to supplying data with regard to the total density of traffic in all parts of the Federal-aid system within the area, the Western States survey will also furnish much valuable information in regard to the types of vehicles that compose the traffic, whether passenger automobiles, trucks, or busses, the number of persons transported by the passenger-carrying vehicles, the number of common-carrier trucks and busses, the origin and destination of all vehicular movements, and in each State the percentages of interstate and intrastate traffic.

MICHIGAN TRAFFIC SURVEY

Toward the close of the fiscal year arrangements were completed for another type of traffic survey to be made in Michigan in cooperation with the State highway department of that State.

This survey, which is to begin with the opening of the new fiscal year, will have for its principal object the determination of several facts with regard to the character and distribution of traffic on State and local roads and city streets which may have a bearing upon the future distribution of the cost of road improvement within the State.

The survey on the rural roads, which will be continued for a whole year, will cover all roads of both State and local classification in selected representative townships in each county of the State. The princpial object of this part of the survey will be to determine, with respect to both State and local roads in each county, what part of the traffic that uses them originates within the county and what part comes from without the county borders. Such a classification of the vehicles can be conveniently made in Michigan by simply noting

certain significant figures of the license numbers carried by all vehicles, since the numbers are assigned according to a code which makes identification of the county in which the owner of each vehicle resides a simple matter.

By employing this means of identification it will be possible to determine what part of the traffic on the roads in each county originates within the county and what part comes from without the county.

It is known from observations made in many States that the traffic generally to be found on a State highway system, made up of the main intercity roads, is a comparatively far-ranging traffic, and that it is composed for the most part of city-owned vehicles. On parts of the State highway system within any particular county it is known in a general way that a large part of the traffic comes from cities within or outside of the county and much of it from without the county. Although there have been few accurate determinations of the character and source of traffic on local roads in any State, it is generally assumed that the roads of this class in the great majority of counties serve a traffic that is predominantly of intracounty origin.

This difference, believed to exist between the origin of the traffic on State and local roads forms the ethical basis of the different measures provided for the financing of State and local road improvement. In all States the State road improvements are supported in the main by funds derived from State taxes, to a large measure taxes on motor vehicles and their fuel. The improvements of local roads are quite generally financed with local funds raised mainly by the taxation of property within the county or other local taxing unit, supplemented to a limited extent by State aid or a share of the motor-vehicle revenue.

In recent years, however, there has been an increasing demand by county and township officials and the representatives of rural precincts in the State legislatures that a greater portion of the State collected revenue be applied to the improvement of local roads. Such demands are usually predicated upon the assumption that the local roads are required to serve a considerable traffic from outside the local taxing jurisdiction and that the State as a whole should compensate the local government in greater measure for the highway service thus afforded to other than local vehicles.

Such a claim is now being pressed in Michigan, and the purpose of the survey is to ascertain the facts that will indicate whether there is reasonable and equitable basis for it.

To provide a similar basis for legislative action on the appeal of the cities which also claim a share of the State revenue in consideration of the use of their streets by rural vehicles, a special intensive survey will be made at the close of the count on the rural roads in seven representative cities of the State. The purpose of this survey will be to ascertain the relative use of the city streets by vehicles owned within and outside of the several cities.

STUDY OF COMMON-CARRIER TRUCK AND BUS OPERATION

In cooperation with the Bureau of Foreign and Domestic Commerce of the United States Department of Commerce an investigation of the use of the highways by common-carrier trucks and

busses was begun during the fiscal year. Certain general information with regard to such operations has already been obtained by means of a questionnaire addressed to a large number of operators. This will be supplemented during the ensuing year by information in greater detail to be obtained by personal solicitation from a smaller number of representative concerns.

The purpose of this investigation is to develop information with regard to the costs of such operation, especially the influence upon such costs of the condition of the roads, the regularity of the service, the types of vehicles employed, the loads carried, the extent to which the service competes with and supplements rail and water common-carrier service, and other facts desirable and necessary as a basis for the provision of adequate highway service and the equitable and reasonable taxation and regulation of the highway common carriers.

HIGHWAY TRAFFIC CAPACITY INVESTIGATION

In the latter part of the fiscal year the bureau entered into a cooperative agreement with the University of Maryland under which the two agencies will conduct an investigation to determine the volume of traffic that can be economically served, without congestion, by roadways of various widths under a variety of conditions.

It is expected that this investigation, which is being conducted in a number of Eastern States and will be completed during the next fiscal year, will establish a usable relation between the volume of traffic and the width of roadway required to serve it. It will also supply important information in regard to the effect of crossroads, railroad crossings, traffic lights, electric-railway loading platforms, and other obstructions to the free flow of traffic.

STUDIES OF HIGHWAY-PRODUCTION PROBLEMS

The studies of highway-construction operations and equipment and the management of construction work have been continued along the lines developed and reported in previous years. They have a dual purpose: (1) To develop and prove the various possibilities of enhancing the efficiency of road-construction operations of all kinds, and (2) by repeated demonstration of these possibilities on all kinds of work in all parts of the country, to disseminate a knowledge of the more efficient methods and promote their adoption in road-construction work generally.

The latter purpose is achieved in several ways. The contractors with whom the bureau cooperates acquire a knowledge of the methods employed in analyzing the various operations, detecting losses and waste motion, and ascertaining the changes and adjustments of plant and working force needed to improve efficiency. The better methods of operation developed by the demonstrations invariably become the standard practice of these contractors in their subsequent work.

While the number of contractors with whom the bureau can cooperate thus directly is limited, the benefits of the studies are extended to a constantly increasing number of the most progressive road builders by means of the published reports and by papers presented by representatives of the bureau at meetings of contractors and highway engineers. The various associations of contractors

have manifested a keen interest in all phases of the work and have made it the subject of discussion at many of their meetings.

Disseminated in these ways, the influence of the studies is apparent in much of the current road work conducted in all parts of the country, and their influence may be expected to extend in ever-widening circles in the future as a result of the impressions now being made upon the minds of the young men of the on-coming generation of engineers and contractors.

The results of the studies have been incorporated in college textbooks, and the original reports of the bureau are used as texts in many of the schools. Engineering students are thus quite generally instructed in the principles of construction efficiency, and to a limited group of selected students each year the bureau provides an opportunity to observe the application of these principles on actual construction work. These young men, chosen at the end of their junior year at college, are given temporary appointments as student engineers in the bureau and are assigned as assistants in current production studies. Those who manifest aptitude for the work and wish to continue in highway engineering as a profession are reappointed permanently when they have received their degrees and again assigned to the production studies for a further training period of about two years. Many of these young men remain with the bureau and are placed in higher positions in the service as opportunity offers. Others accept positions with State highway departments or with contractors.

The production studies are conducted on selected construction projects of all types in all parts of the United States. As an instance of the success often met with in the work there may be cited a job in southern California recently studied by an engineer of the bureau for a period of about nine weeks.

Two shovels were employed on this job, which was well above the average in respect to management and personnel. One of the shovels was new and manned by an exceptionally experienced crew, while the other had had two years of use and was manned by a less expert crew. As the material in which the shovels worked was practically the same throughout the studies, changes in the rates of production can not be ascribed to differences in material.

Studies were made on both shovels, and as the causes which were holding down production became apparent, suggestions were made to the management as to how they might be reduced or eliminated. The results were most gratifying. For the second shovel—the older one—the average rate of production during the first three weeks was 65, 91, and 106 cubic yards per working hour, respectively, an average of 87 cubic yards per working hour during the whole period, and a progressive increase during each week. But the improvement did not stop here. The studies and suggestions for still further increases in the rate of production were continued during the following five weeks, with the result that during the last three weeks the average rate of production reached 109, 120, and 123 cubic yards per working hour, or an average of 117 cubic yards per hour for the last three weeks, as compared with 87 cubic yards per hour during the first three weeks of the studies. This represents an increase of over 34 per cent in the average rate of production as between two equal and

fairly comparable periods, due entirely to the elimination of time losses and waste motion, the better coordination of dependent operations, and the proper training of the personnel.

The other shovel—the new one, manned by personnel unusually well trained and experienced—started with a higher rate of production, yet it was still possible by careful study and close attention to the coordination of operations and elimination of minor time losses to increase the rate materially. Thus during the first three weeks of the studies the average rate of production for this shovel was 115, 158, and 131 cubic yards per working hour, or an average rate of about 135 cubic yards per hour. This is an unusually high rate for the class of material in which the work was done; nevertheless, the average rate during the last three weeks rose to 160, 150, and 156 cubic yards per working hour, or an average of 155 cubic yards per hour for the entire three weeks. This is an increase of about 15 per cent in the average rate of production of a crew already exceptionally well trained and experienced and working under alert, capable management. Daily rates of operation as high as an average of 239 well-filled dipper loads per hour were attained with a 1¼-yard shovel loading into 5-ton trucks.

Not all jobs, of course, have yielded equally gratifying improvement in the rate of production. On the other hand, very few projects have been found on which an increase of 10 per cent or more in the rate of production was not possible without any corresponding increase in the cost of operation.

In the construction of concrete pavements the pace is set by the mixer. Nothing of value is accomplished if materials are delivered to the mixer at a faster rate than they can be converted into concrete, and the placing and finishing operations can not proceed at a more rapid rate than the output of the mixer will permit. The rate of output depends directly upon the time required by the mixer to produce a uniformly mixed batch of concrete. In order to insure the production of satisfactory concrete, the specifications always require a certain minimum mixing time, varying from 60 to 90 seconds and occasionally longer periods. As the prescribed period definitely limits the output of the mixer and the whole construction operation, it is important to ascertain what period of mixing is actually required to produce uniform concrete of good quality.

Accordingly, extensive studies of the effect of the mixing time on quality and unit cost of concrete mixed in standard paving mixers under actual field conditions were begun in 1924. The result of the first four years' work was published in Public Roads, volume 9, No. 5. The work has been continued during the past fiscal year, and the studies have now been carried to a point where they show clearly that not only is a 60-second period of actual mixing ample but that on a well-managed job any reduction in longer mixing cycles can be translated into additional production and a corresponding decrease in the unit operating cost. Thus if a well-managed job working under specifications which require a mixing cycle of 75 seconds is regularly producing at an average rate of, say, 40 batches per hour and an operating cost of $1 per batch, then it may reasonably be expected that if the specifications are changed to permit the use of a 60-second mixing cycle the rate of production will rise to about

50 batches per hour, and the operating cost will drop to about 80 cents per batch.

As a phase of the study of methods of constructing low-cost bituminous roads which is being conducted in cooperation with various agencies, the methods of production analysis previously applied to other types of construction have recently been employed in the study of the methods used in these lately developed types. Some of the operations, such as those of mixing oil and aggregates in place on the road, present problems which had not arisen in connection with any other type of construction. Consequently, standardized equipment was lacking, and various kinds of implements intended originally for other purposes had to be adapted to this new work, often with obvious lack of efficiency. Studies are, therefore, being carried on to determine the most efficient methods of performing the operations which are really necessary to obtain the desired results and the equipment best adapted to perform these necessary functions at the lowest possible unit cost. To date most of the work has been devoted to obtaining definite data on the various methods employed and to studies of the possibilities offered toward increased rates of production and lower operating costs. These studies, however, already indicate that in many lines of this work considerable improvements are possible, especially in regard to a better coordination of dependent operations and a fuller utilization of the productive capacity of the controlling equipment.

During the past year the bureau has assisted several State highway departments in the installation of uniform accounting and statistical procedures designed to supply full and complete records of expenditures and accomplishments in the fields of highway construction, maintenance, and administration. Basically, this work consists of the development of standard definitions of the various activities in which the several State highway departments are engaged and then setting up a system of standardized accounts which will not only fully meet all the accounting requirements of the department and provide in readily available and practical form complete statistical information on any or all desired lines of activity, but will at the same time be adaptable for use in connection with modern bookkeeping and tabulating equipment in order to give a prompt and accurate service at the lowest possible cost. Further development of this work and the adoption of such uniform systems of accounting by the several States will make possible an intelligent comparison of costs of construction and maintenance of roads as carried on in each of the States, a comparison which is not possible at present because of the dissimilar form of the available records. Such comparisons, when they can be accurately drawn, will be helpful to all States as an index of the relative efficiency of their practices and will be especially useful as a means of supplying data not now available with regard to the cost of maintaining the various types of roads under various conditions of traffic, climate, topography, and soil. During the past year expert assistance along these lines was given to the State Highway Departments of Alabama, Georgia, Illinois, Indiana, Oklahoma, South Carolina, and Tennessee.

PHYSICAL RESEARCH

SUBGRADE INVESTIGATIONS

The general problems involved in the subgrade investigations and the complicated nature of these studies have been described in previous reports. During the year these investigations have been continued, as in the past, with the cooperation of the Bureau of Chemistry and Soils and various State highway departments and educational institutions.

Steady progress is being made in the development of new and useful information, and the advance that has been made toward a more accurate conception of the characteristics of subgrade materials as they influence highway construction is very satisfying.

The stability of the subgrade or its ability to resist lateral flow under load, as it is now understood, depends upon two mechanical properties, cohesion and internal friction. Cohesion, that part of the resistance to distortion which is independent of the external pressure acting on the soil, is furnished by the soil particles of small size such as clay and colloids. Internal friction, that part of the resistance to distortion which increases in direct proportion to pressure, is furnished by the larger soil particles such as sand grains. The cohesion of clays varies with the character of the colloids present, and the internal friction developed by sands varies with the angularity and surface texture or roughness of the individual sand grains. This knowledge is important with respect to the design of stable subgrades and low-cost road surfaces such as those of sand-clay and topsoil, since it furnishes a basis for the determination of the relative amounts of sand and clay required to produce stability, depending upon the cohesion and internal friction of the particular materials available.

It is now understood that volume changes in subgrades, in the absence of frost, are caused entirely by absorption of moisture and its loss by evaporation and that there is a minimum limit of moisture content below which the volume of a soil can not change. Above this shrinkage limit the loss in volume of a soil due to loss in moisture content is equal to the volume of the moisture lost. Practically this information suggests that the proper treatment of subgrades likely to be subject to detrimental volume change is to protect them by some means which will prevent the absorption of water and its loss by evaporation.

It has been found that the presence of mica, peat, or other materials which produce a porous soil condition, will result in a subgrade having detrimental elastic properties. Such elasticity may produce failure in pavements of flexible type such as macadam, and excessive early cracking in concrete pavements. The preliminary identification of elastic subgrades is important both from the standpoint of the preparation of the subgrade and the selection of a suitable type of surfacing. For instance, unless an elastic subgrade has been stabilized by treatment, an attempt to construct a macadam surface may result in failure. Also, attempted consolidation with a heavy roller, which is beneficial for a nonelastic subgrade, in the case of an elastic subgrade may result in a rebound after rolling and cause early cracking in newly laid concrete pavements.

Excessive heaving due to frost action is now understood to be due to the formation of well-defined ice layers in the subgrade and is attributed to the following physical phenomena:

(1) The ability of water particles contained in large soil pores to freeze at about normal freezing temperatures.

(2) The ability of water contained in the very small soil pores to resist freezing at abnormally low temperatures.

(3) The ability of the large water particles, upon freezing, to draw to themselves particles of water from the capillary pores which do not freeze at normal freezing temperatures. This water from the capillary pores freezes upon coming in contact with the larger water particles already frozen and adds to the size of the existing ice crystals.

(4) As water is drawn to the growing ice crystals from the capillary pores the supply may be replenished by water drawn up by capillary action from the ground water level. The continuation of this process, under favorable conditions, may cause roads to heave as much as several feet.

It has been found that neither coarse-grained sands nor cohesive clays are associated with detrimental frost heaving. On the other hand, porous silts and porous clays, low in cohesion, are subject to detrimental heaving in the presence of the certain moisture and temperature conditions.

An understanding of the causes underlying the occurrence of frost heaving and the ability to identify portions of the subgrade where heaving is likely to occur are of great practical value. For example, when gravel or other low-cost surfaces are to be constructed on silts or porous clays it may be necessary to provide an expensive drainage system to lower the ground water to an extent which will cut off the supply of water that would cause excessive heaving. In contrast, when these surfaces are to be constructed on cohesive clays, where trouble may be expected more as a result of volume change due to variations in moisture than as a result of frost action, a protection of the subgrade to prevent the entrance of water from above may be more effective than an expensive subdrainage system.

With respect to drainage it is now understood that certain soils, such as heavy clays, can not be effectively drained and that the flow of ground water is through porous layers of soil. Completely to intercept the seepage of ground water, drains must be laid at an elevation corresponding to the elevation of the lower surface of the porous soil layer and the upper surface of the impervious undersoil. The significance of this knowledge with respect to road construction is that drains may be ineffective unless placed at exactly the proper depth and that this depth can be determined only by soil examinations made at every location at which drains are to be installed.

The methods used in classifying and identifying subgrade soils for highway purposes are radically different from those employed by the agronomist in the study of soils for agricultural purposes. The latter is interested primarily in the measurement of the factors which indicate the ability of a soil to nourish plant life. The highway engineer must be able to identify the physical properties which govern stability, volume change, elasticity, frost heaving, and drainage. The identification of these properties by means of simple tests is a new

science. As the progress being made demonstrates more and more the practical value of this work with respect to road construction the greater becomes the number of problems presented for solution.

LOW-COST ROAD INVESTIGATIONS

The development of satisfactory low-cost types of surfacing for light-traffic roads is a matter which will continue to demand the increasing attention of highway engineers. Roads of this character constitute important links in the highway transportation system, and relatively inexpensive improvements which will render them passable at all seasons of the year have become a necessity in many locations. The investigations of the bureau, designed to add to the existing knowledge of this subject, are being continued, and new studies are being undertaken as the conditions warrant.

Several experimental construction projects were described in the report of last year. Of these, the project in California, conducted in cooperation with the division of highways of the California Department of Public Works, involves mixed-in-place treatments and surface treatments of crushed rock and crushed gravel surfaces with different types of bituminous materials. The mixed-in-place treatments were completed during the fall of 1929 and give preliminary indications that some of the hitherto untried materials may prove very effective in this type of construction. Some of the surface-treated sections were completed during the spring and the rest will be completed during the summer of 1930. The publication during the next year of a report describing the materials and methods employed in the various sections is contemplated.

The experimental road in the sand-hill area of Nebraska for the study of bituminous treatments of roads composed almost entirely of sand was partially constructed during the fall of 1929 and the construction will be completed during the summer of 1930. The condition of the sections already completed, together with the observed behavior of the earlier experimental section in this area, now nearly two years old, encourage the belief that an economical type of construction will be developed which will be useful in improving highway conditions in this area and others of similar character.

In South Carolina the construction of different types of bituminous surfacings on marl and sand-clay bases, in an experimental project 4½ miles in length, was completed during 1929. There are now under observation in this State three experimental projects, constructed and maintained in cooperation with the State highway department, having a total length of approximately 32 miles. It is anticipated that progress reports of this work will be published during the next fiscal year.

Preliminary arrangements are being made to extend the study of low-cost road construction to Colorado where, in cooperation with the State highway department, it is proposed to build an experimental section about 3 miles in length. This will have a gravel surface, treated with bituminous materials by the mixed-in-place method. Among other features to be studied will be the possible utility of types of bituminous materials which have not been used before in either ordinary construction or experimental work.

The study of methods of bituminous low-cost road construction developed by State highway departments and local authorities in various parts of the country, begun during the preceding fiscal year in cooperation with the asphalt institute, have been continued throughout the past year. These methods have been developed to meet conditions prevailing in the particular localities, with results more or less satisfactory. Many of them have much in common but differ in details regarded as of importance by the local authorities. By studying and comparing them the bureau and its cooperators hope to be able to weigh the relative advantages of each method, to gain a first-hand knowledge of the variable conditions that must be dealt with, and to obtain suggestions here and there which, when combined, will lead to the development of more effective methods than have yet been developed. The definite ideas with respect to new and potentially valuable methods and materials, developed as a result of these broad studies of prior experience will be subjected to intensive study and test in the laboratory and in experimental roads to be constructed subsequently under carefully controlled conditions.

During the past year such broad studies have been made of methods of bituminous treatment of sand-clay and topsoil roads developed in Florida and South Carolina, of the oil treatment of earth roads as practiced in Illinois, and the so-called retread method of restoring worn stone and gravel roads as employed in Indiana. A report of the Florida and South Carolina investigations has been published.

During the ensuing year it is planned to continue with studies of the process developed in Minnesota and known as the gravel-blotter method, by which remarkably satisfactory improvements have been made at very moderate cost; and the study of retread types will be extended into Kentucky, where the method employed differs in a number of particulars from that used and previously studied in Indiana.

MOTOR-VEHICLE IMPACT INVESTIGATIONS

For a number of years the bureau has been investigating the impact of motor vehicles (particularly motor trucks of the heavier types) as a force destructive of road surfaces. Much of this work has been done in cooperation with the Society of Automotive Engineers and the Rubber Manufacturers Association.

These investigations have been of a pioneer nature and have led, of necessity, to the devising of instruments and apparatus for the determination of the forces involved.

In order that the accuracy of the data, obtained with these devices, might be definitely established an arrangement was made with the Bureau of Standards for a cooperative investigation of the accuracy of all the instruments which had been used or proposed for use in this work. A very searching study was made and during the past year was completed.

The report of this instrument investigation has cleared away all uncertainty regarding the limitations of the instruments, has established the probable accuracy of future work, has allowed the release of completed reports and the resumption of active investigation along lines previously authorized.

Three reports have been prepared for early publication. The first is a summary report of the instrument investigation, with special emphasis on the relation of this work to the other data on motor-truck impact. The second report discusses the effect of the thickness of the tread rubber of solid and cushion truck tires on the magnitude of the impact reaction which may be expected, and the third is an account of a study of the interrelationship of the four major variables which determine the magnitude of the impact reaction. These four variables are wheel load, tire equipment, vehicle speed, and road roughness. The third report presents data showing how each of these important factors is related to the other.

INVESTIGATIONS OF CONCRETE

A number of investigations of Portland-cement concrete, to which reference has been made in previous annual reports and from which it is hoped to obtain a more complete knowledge of how to use this important structural material in highway work, have been continued. These investigations include studies of the most desirable proportions of materials to use in concrete-pavement mixtures, with special reference to the effect of increasing the amount of coarse aggregate; studies of conditions affecting the resistance of concrete to repeated frost action, with special reference to the influence of the kind of aggregate used; an investigation of sands used in concrete-pavement construction for the purpose of ascertaining the influence of the type of sand on the quality of concrete; and studies of various methods of curing concrete pavements in an effort to ascertain which, if any, of the numerous methods now being actively promoted are as satisfactory as the present standard method of covering the fresh concrete with a layer of damp earth kept wet for several days.

The half-mile experimental pavement to which reference was made in the report of last year has been constructed, and the tests have been practically completed. Complete analysis of the data has not yet been accomplished; it is probable, however, that concretes containing considerably more coarse aggregate than the mixtures now usually employed may be safely used.

The severe weather conditions to which concrete pavements are subjected, especially in the Northern States, with the consequent tendency to disintegrate through frost action emphasizes the importance of studying conditions affecting durability. Studies of this character are necessarily of long duration on account of the time required to produce conditions in the laboratory which are comparable with actual weathering. For this reason the first series of tests conducted by the bureau along this line, which was started several years ago, is only now being completed. These tests were for the purpose of ascertaining how the resistance of concrete to frost action is affected by the kind of coarse aggregate used. The tests indicate the extreme importance of determining definitely in advance of any construction whether the coarse aggregate to be used is of a durable character. Nondurable aggregates, even though they make concrete of the required strength, should never be used.

During the summer of 1926, 40 concrete test slabs 200 feet long and 2 feet wide were constructed at the Arlington Experiment Farm, Rosslyn, Va., and subjected to a wide variety of curing treatments.

For three and one-half years these sections were closely observed to determine the effects of the various curing methods. Data were obtained on the volume change, moisture loss, surface hardness, and many other characteristics of the several sections. A detailed report of these studies has been published during the past year; the information contained in that report is a distinct contribution to the general knowledge of the subject of the curing of concrete pavements.

The bureau has also cooperated with the Tennessee Department of Highways in a study of curing methods as applied to actual pavements. The investigation, which has been completed recently, was conducted on a 17-mile length of concrete pavement in southwestern Tennessee. Twenty-five different methods of curing were employed. In the report, which is now being prepared for publication, the analysis of the relative efficiency of the various curing methods will be based on a consideration of such factors as the strength of the concrete specimens and transverse cracking and surface hardness of the pavement.

A device, utilized in both of the above curing investigations, has been developed for indicating the surface hardness of concrete pavements. This apparatus is very simple in principle and is portable, so that it may be used on any pavement, the test being made in place without damage to the pavement. The device consists of three hardened steel wheels, bearing a constant load, which are caused to roll slowly around a circular path (20 inches in diameter) on the pavement. These wheels cause a narrow groove to be worn in the pavement and the depth of the groove after the completion of a specified number of revolutions is a measure of the hardness of the pavement surface. The test was devised to indicate the effect of curing treatments on surface hardness but may be used to study other factors, such as aggregates.

HIGHWAY-BRIDGE INVESTIGATIONS

In the last annual report, a program of bridge-floor slab tests being made in cooperation with the Port of New York Authority was described in some detail, and the importance of the tests was noted. These tests have been virtually completed, and a comprehensive report is being prepared. In this program three different aggregates were used, and the concretes were placed by each of four methods. Strength data were obtained for both plain and reinforced slabs. A large number of bond tests of embedded steel were made and information developed on the elastic and other properties of the concrete obtained by the various combinations and methods of placing. There is a demand for information which will assist in the development of bridge-floor slabs of less weight than those ordinarily employed, and the report of this investigation will add materially to the data now available.

Another investigation having a similar purpose is to be carried on during the next fiscal year in cooperation with the authorities of Allegheny County, Pa. A newly developed type of steel and concrete bridge-floor slab of extremely light weight has shown satisfactory strength in laboratory tests under static loads. To observe its resistance to impact forces, such as would be developed by the

wheels of heavy motor trucks, impact tests are to be conducted on an experimental section of bridge floor about 15 feet square.

In France, the Freyssinet method of concrete-arch construction has been in use for some years and has been employed in the construction of some of the longest concrete-arch spans in the world. By means of hydraulic jacks placed at a transverse joint at the crown, the two halves of the arch are forced apart and lifted from the centering which supports the arch ribs during construction. This permits the final placing of the axis of the arch in any predetermined position, thus relieving the structure of certain stresses which would otherwise occur and permitting a more accurate determination of stress effects than is possible in the case of concrete arches constructed by usual methods. The method has never been employed in bridge construction in the United States. During the year arrangements for a detailed investigation of its advantages have been made. This investigation, to be made in cooperation with the Oregon State Highway Commission, will be conducted in connection with the construction of a large concrete-arch highway bridge in Oregon, and will involve accurate measurements of stresses and deflections in the structure. The substructure of the bridge is to be completed during the season of 1930, and the investigational work will be done during the season of 1931 in connection with the construction of the superstructure.

DIVISION OF AGRICULTURAL ENGINEERING

IRRIGATION INVESTIGATIONS

DUTY-OF-WATER STUDIES

Studies pertaining to duty of irrigation water in its various forms continue to occupy a prominent place in the activities of the division of agricultural engineering. The last of a series of five reports on the irrigation requirements of western lands, begun several years ago, is nearing completion. The summation of the water allotments discloses the fact that water is available for the eventual irrigation of 62,000,000 acres, when the Nation needs the products which this acreage would yield.

Where the waters of the San Joaquin River meet those of the Sacramento River in California a broad delta has been created, about half of which has been protected by levees and rendered highly productive by drainage and irrigation systems. Part of the reclaimed area is below tide level and the rest but slightly above. To determine accurately the quantity of water transpired by cultivated plants on this area it is necessary to grow specimens of each kind in tanks. The native vegetation, such as tules and cattails, which flourish on the unreclaimed areas, has likewise been subjected to similar treatment with rather remarkable results. The records for 12 tanks in which such vegetation was growing show that for the month of August, 1929, alone the average water loss resulting from evaporation and transpiration was at the rate of 2.65 acre-feet per acre. About 8,000 acres are occupied by this worthless growth, and the quantity of water evaporated and transpired from them annually is estimated to be 150,000 acre-feet—sufficient to irrigate adequately at least 60,000 acres of alfalfa.

In southern Oregon the water requirements of pear trees are being determined by ascertaining the relationship between water applied and yield, the moisture content of the soil before and after irrigation, and how water can be made to penetrate heavy soils in order to furnish much-needed moisture to the lower roots.

In southern California a diminution of the available water supply following a series of dry years has aroused a widespread and intense interest in everything pertaining to water. A number of State and Federal agencies have entered this field in an endeavor to contribute aid. The work of this bureau is being carried on along two more or less distinct lines. In one of these an intensive study is being made of orchard irrigation with the object of eliminating much of the customary waste and applying water more effectively and in better time, so as to produce a profitable yield of fruit with less water. The other is more general in character and consists in collecting data to show what becomes of the rain which falls on untillable watersheds sparsely covered by native vegetation. Rainfall penetration in soils and subsoils is being studied as well as the quantity of rain water annually transpired by native vegetation.

For a few years past the precipitation has been subnormal, and very little water falling as rain upon the valley floors in southern California has penetrated within the soil to depths below the roots of plants. As a result the level of the underground water, which forms a supply for pumping, has been lowering and additional means of replenishment have been sought.

WATER SPREADING

In many sections of the West a considerable part, and in some sections the major part, of the irrigation-water supply is derived from underground sources and is elevated by means of pumps. The recent cycle of dry years has resulted in an overdraft upon the underground-water supply and a consequent lowering of the water table. In some cases the economic limit of pumping lift has almost been reached. Near the coast the water table is at or near the ocean level, and unless some means of increasing the underground-water supply or decreasing the demand on this supply is employed, salt water will come in from the ocean and impair the quality of underground water to such an extent as to render it valueless for agricultural purposes.

The results of rainfall-penetration studies have disclosed certain facts regarding the rate of replenishment from this source to the underground-water supply, and to augment this replenishment the attention of this bureau and other agencies has been directed toward the spreading of flood waters over porous areas associated with underground-water basins.

Study of the problem of water spreading and its effectiveness has just been undertaken, but the practice in southern California dates back more than 40 years. The results of the preliminary investigational work promise much for this method of increasing the present available water supply in many Western areas.

LOSS OF WATER BY EVAPORATION

A report giving the results of research investigations of the factors affecting rates of evaporation from a free-water surface has been

submitted for publication. A reservoir has been found that is geologically "tight" and has an inflow during the summer season that can be accurately measured and an outflow that can be controlled. Plans have been made to carry on intensive evaporation studies upon it.

PUMPING FOR IRRIGATION

There are many faulty installations of pumping equipment, and it is not infrequent to find the water elevated appreciably higher than necessary, thereby adding to the power cost. While much time and means have been devoted to the improvement of pumping equipment, too little attention has been paid to the economical utilization of the water, and frequently wasteful usage by the irrigator more than offsets mechanical betterments.

During the last year or two it is probable that more land in the western part of the United States has been drained by pumping than by gravity. Where conditions are favorable to pumping, that method is more satisfactory than gravity drainage, largely because it is possible to lower the general water surface of the underground water to a greater depth and at much less expense by means of pumping. Since this means of drainage was first undertaken in the Salt River Valley of Arizona, it has extended into several of the Western States, while in California and Idaho large areas of water-logged land have been reclaimed by this means. In cases where the underground water is suitable for irrigation, the operating expense of the pumping plants is frequently wholly offset by the utilization of the pumped water for irrigation.

CUSTOMS, REGULATIONS, AND LAWS RELATING TO IRRIGATION

Studies begun during the fiscal year 1928 in cooperation with the Oregon Agricultural Experiment Station, involving the engineering, agricultural, and general economic status of various irrigation districts in Oregon, were continued during the past year at the invitation of the State reclamation commission. Reports on several districts begun during the previous fiscal year were completed and submitted to the State reclamation commission, and two additional studies were undertaken. Negotiations are now in progress between most of the districts and the holders of their bonds to effect settlements on bases ascertained in these studies to be economically justifiable. Invitations have been received to undertake similar studies in connection with defaulting districts in several other States.

The field work and manuscript for a revision of Department Bulletin No. 1177, Irrigation District Operation and Finance, were completed during the fiscal year. In connection with this project, a comparative summary, by topics, of the irrigation district laws of all 17 Western States has been undertaken and is nearing completion. This will be submitted for publication during the current year. A technical bulletin, entitled "Commercial Irrigation Companies," was issued during the year.

DESIGN, INVENTION, AND TESTING OF APPARATUS

Studies of the Parshall measuring flume have been continued, especially in connection with the large sizes. Investigations regard-

ing this type of measuring flume have been nearly completed, and a manuscript on large flumes will be prepared for publication during the winter of 1930–31.

Studies were continued on the adjustable-tube measuring device, which is intended for use on small water supplies and for individual use.

FLOW OF WATER IN DITCHES, PIPES, AND OTHER CONDUITS

A bulletin on the flow of water in riveted steel and analogous pipes was issued during the fiscal year.

The study of the flow of water in flumes is being continued, and special attention is being given to "entrance losses." A design for entrances to flume sections has been developed which results in a more nearly straight-line approach of the water to the flume section, thereby increasing the carrying capacity.

RECLAMATION OF ALKALI LANDS

Investigation of this problem in cooperation with the Idaho Agricultural Experiment Station will have continued for a period of five years at the end of the 1930 season. During the fall of 1929 a pumping plant was installed on the experimental tract for the purpose of supplementing the gravity drainage system. This plant has been in continuous operation during the first half of the calendar year 1930. It is expected that a progress report will be prepared for publication at the close of this season.

DRAINAGE OF LANDS OVERLYING ARTESIAN BASINS

For the last three years the bureau, in cooperation with the Utah Agricultural Experiment Station, has been studying methods utilized for the drainage of water-logged lands overlying artesian basins, the particular basin under observation being in Cache Valley, in northern Utah. The artesian basin is generally about 50 feet below the surface, and the soil overlying this basin is for the most part dense material. It was soon found both theoretically and by trial that gravity drainage was not practical. The problem, therefore, became one of relieving the hydrostatic pressure of the underground water, since observation had shown that the land was water-logged by the upward movement of water from this artesian basin. Numerous test wells were driven over a considerable area for the purpose of observing the hydrostatic pressure. A considerable number of 2-inch and 4-inch wells were sunk into the basin, and their effect upon the pressure was observed. There is now in course of construction an 8-foot well that will reach into the underground gravels. There will be installed in this well a pumping unit of sufficient capacity to lower the water in the well to such depth as may be desired, and the effect upon the surrounding observation wells will be determined. It is expected to complete this work during the season of 1930.

SEWAGE IRRIGATION

Distribution of sewage on cropped fields is an important engineering problem that has been under study for the past two years at Vineland, N. J., in cooperation with the New Jersey Agricultural

Experiment Station. Sewage from a population of 8,000 is disposed of on an irrigated farm. Equal division of the effluent into small streams of 20 to 30 gallons per minute each has been effected by laying a 12-inch pipe line fitted with cast-iron outlets. These are all placed at the same elevation, and the discharge is admitted to furrows spaced 3 feet apart. By keeping the furrows unobstructed the sewage travels satisfactorily for a distance of 300 or 400 feet. Sludge, always a difficult problem, is pumped into the effluent from a settling tank and carried for more than a half mile through terra-cotta pipe and open ditch and spread over a specially prepared field, where it is plowed under before the field is planted.

DRAINAGE INVESTIGATIONS

RUN-OFF MEASUREMENTS AND DITCH CAPACITIES

Investigations relative to rates of run-off and channel capacities were continued to January 1 on 10 watersheds and their channels in northeastern Indiana. All equipment was then moved to a location in northwestern Ohio. The Ohio project includes nine watersheds and channels offering great contrast in surface features to the areas previously investigated.

Considerable time has been given to a study of the relationship existing between rates of rainfall and run-off, with regard to watersheds having great range of size. A report of the Indiana investigations which present correlations between these factors that can be used as a basis for computing run-off expectancies has been prepared.

The investigations of the run-off from Ralston Creek, Iowa, a small stream draining an agricultural area of 3 square miles, were continued during the fiscal year in cooperation with the University of Iowa. By means of a weir-control station, nine rain gages, and a water-stage register, accurate information in regard to the relation of run-off to rainfall is being obtained. A report covering the last five years of this study is now being prepared.

OPERATION AND MAINTENANCE OF DRAINAGE PUMPING PLANTS

Studies of drainage pumping plants along the Illinois River and along the Mississippi River between St. Louis and Savanna, Ill., have been continued. Five progress reports have been prepared covering this investigation, and the manuscript for a bulletin based on the investigation is in preparation. It has been found that there is little difference between the average unit costs of pumping with electric power and oil-engine power provided comparisons are based on the pumping of equal quantities of water. The minimum unit costs were obtained by an oil-engine plant which had been built at a very low cost per horsepower. This suggests that greater economy in the construction of the pump house, foundation, and suction bay is desirable in order to reduce the fixed charges. The operating expenses of the steam plants are greater. Many plants of this type have been abandoned since 1920, and others are operated only for emergency pumping. It has been found that the operating efficiency of the plants can usually be improved by better supervision, by more efficient speed regulation, by proper maintenance, or by the substitu-

tion of more economical equipment. Greater pumping capacity is needed in some districts in order to maintain a lower water level and obtain better drainage.

FLOW AROUND BRIDGE PIERS AND OVER EMBANKMENTS

In continuation of studies begun in 1928 on the obstruction of bridge piers to the flow of water numerous experiments were made at the hydraulic laboratory of the University of Iowa, in cooperation with the university, on additional models of various pier shapes. Coefficients were developed for use in hydraulic formulas for computing backwater caused by bridges.

Hydraulic tests on the flow of flood water over full-size sections of single and double track railway and highway enbankments were made and coefficients developed for use in hydraulic formulas for computing the quantity of flood water passing over such embankments. The results have been published.

Experiments on the obstruction of single-track pile trestles to the flow of water were made on both a full-size pile trestle and a one-fourth size model. The effect of end abutments was also investigated. Hydraulic-formula coefficients were also derived for use in connection with such structures.

DURABILITY OF DRAINTILE

The bureau, in cooperation with the Department of Agriculture and the department of drainage and waters of the University of Minnesota, has continued the investigations at university farm, St. Paul, relative to the durability of draintile under exposure to various conditions of soil and climate.

Experiments to show the effect of steam curing of concrete at temperatures up to 350° F. for a wide range of time periods were conducted in considerable detail and conclusions drawn as follows:

(1) Solely from the standpoint of strength, nothing is gained by curing concrete in water vapor at a temperature much above 155° F., and little is gained, even at this temperature, by prolonging the curing period beyond 48 hours.

(2) Solely from the standpoint of resistance to sulphate waters, nothing is gained by increasing the temperature of the water vapor in which concrete is cured until 212° F. is reached. Between 212° and 285° it may now be definitely stated that increased resistance follows increase of curing temperature.

DRAINAGE INDEX OF SOILS

The effort to check the accuracy of the elutriation method of determining the proper spacing of drains has substantiated the belief that the method is safe. It appears that drains placed at a suitable depth and the indicated distance apart for that depth will provide satisfactory drainage. However, it also appears that such spacing may be unnecessarily close and therefore unduly expensive. Because of this fact and because of the known limitation of the elutriation method in dealing with some of the lighter soils that may need drainage, an effort is being made to find a method that applies to both

light and heavy soils and that is accurate in its indication throughout the range of soil types found in agriculture. Several methods that offer promise are now being investigated in the laboratory.

CONTROL OF SOIL EROSION

Observations on the special soil-erosion plots at Raleigh, N. C., were continued. Winter cover crops were found to have only a slight effect in controlling erosion, effecting a reduction of only 10 per cent. Losses of soil from corn and cotton plots when the two crops were grown in rotation were practically as large as when these crops were grown on the same land continuously. Grade of the terrace channel was found to affect run-off from terraced areas considerably.

The appropriation act for the fiscal year 1930 continued the special fund to be expended by the department in making soil-erosion and moisture-conservation investigations. The fund was allotted to the Bureau of Public Roads, the Bureau of Chemistry and Soils, and the Forest Service. The investigations on the soil-erosion experiment farm at Guthrie, Okla., were continued in cooperation with the Bureau of Chemistry and Soils and the Guthrie Chamber of Commerce. During the period April 26 to May 17, 1930, a total rainfall of 11.42 inches was measured at this farm. This is more than one-third of the average annual rainfall at Guthrie. On May 3, 3.22 inches of rain fell in approximately 1½ hours, 1.8 inches falling in 25 minutes, and 0.5 inch in 5 minutes. Thus the maximum rainfall for a period of five minutes was at the rate of 6 inches per hour. Terraces in the red-plains area of Texas, Oklahoma, and Kansas must be designed and constructed to provide for the run-off during periods of such intense rainfall.

One of the outstanding observations made during the storm period was the relative severity of the erosion on the unterraced land where the surface conditions were the same as on the terraced land. New gullies developed in the unterraced land, and wind-blown soil that practically filled many of the old gullies was washed away, while on the terraced land this wind-blown soil was collected and saved by the terraces.

An experiment designed to determine the relative amounts of erosion from terraced channels with falls of 2 and 4 inches per 100 feet, indicated that between four and five times as much soil was carried away on terraces with the 4-inch fall. Terraces without fall (level) and some with a fall of 6 inches per 100 feet were also included in the experiment, but silt-measuring boxes had not yet been installed on these terraces. The results already obtained show that the grade of the terrace has a very appreciable effect upon the amount of soil removed by run-off water and that the grade should be given careful consideration in the design of terraces, not overlooking, however, the necessity for removing the water in time to prevent overtopping the terrace.

Valuable information was obtained from an experiment on the spacing of terraces 700 feet in length on virgin soil and a land slope of about 5 per cent. The intense rain of one-half inch falling in five minutes was a critical test of these terraces. In the channels of terraces with 5-foot spacing the water reached a depth of nearly 17 inches; with 3½-foot spacing the depth was about 14 inches; and in

the channels of terraces with 2-foot spacing the depth reached was about 10 inches. To provide a margin of safety of 6 inches, the above terraces should be built 23, 20, and 16 inches high, respectively. An examination of the ground between the terraces showed that erosion between terraces spaced 5 feet apart was much greater than that which occurred between terraces spaced 2 feet apart.

A series of laboratory tests was made at the hydraulic laboratory at Iowa City on the silt-measuring apparatus developed for use in soil-erosion investigations. The device was calibrated for field use, both the hydraulic and the silt-measuring characteristics and coefficients being measured and computed. The results of measurements made with this device will be given due consideration in conjunction with the run-off in making recommendations for the spacing and height of short terraces on moderate slopes in the red-plains region.

On the experimental farm near Temple, Tex., which is being operated in cooperation with the State agricultural experiment station and the Bureau of Chemistry and Soils, practically all of the land has been terraced, and experiments have been laid out for the purpose of determining the best design of terrace systems for the black-land region of that State. On May 10 a rain of 5¾ inches occurred, 5 inches of which fell in about four hours. This intense rain caused breaks in one set of terraces, but the damage was due to the silting of the intercepting ditches that had been constructed to provide for the removal of run-off water from outside the area. These ditches have since been enlarged and protected against silting, and no further difficulty is anticipated. No appreciable erosion occurred on the terraced fields, whereas on adjacent unterraced land it was very severe. Observations made after the heavy rain of May 10 showed that on land in corn and cotton, level terraces from 400 to 1,400 feet long with one end open had withstood the test very well, and examination a few hours after the storm ended showed that the water which collected behind the terraces disappeared rapidly. The fact that level terraces on cotton and corn land withstood the storm satisfactorily is rather surprising and appears to indicate that such terraces may be practicable in the black-land area. However, additional records should be obtained before definite recommendations are warranted.

Upon the completion of the construction of the terraces and the planting of the crops the installation of the scientific equipment was started and should be completed early in the fiscal year 1931.

In August, 1929, additional experiments were begun at the Fort Hays Experiment Station in cooperation with the Kansas Agricultural Experiment Station and the Bureau of Chemistry and Soils. A survey and map of the farm has been made and other preliminary work has been done. About 60 acres of comparatively level land has been terraced and about 20 acres has been deep tilled to determine the effect of such work on moisture conservation. Altogether about 100 acres of land has been prepared for experimental work, and the necessary scientific equipment has been installed.

Additional farms have been established near Tyler, Tex., in cooperation with the Texas Agricultural Experiment Station; near Bethany, Mo., in cooperation with the Missouri Agricultural Experiment Station; and near Statesville, N. C., in cooperation with the

North Carolina Department of Agriculture and the North Carolina Agricultural Experiment Station. Surveys and maps of the Tyler and Bethany farms have been completed and other preliminary work has been done. The survey of the Statesville farm was in progress at the close of the year.

Practically all farming operations on the experimental farms are being done with modern farm machinery and a thorough study is being made of the operation of such equipment over terraced land. It has been discovered that some of the machinery that proves satisfactory for ordinary conditions is not flexible enough for operation over terraces and that some changes in design will be required if it is to be used successfully in regions where terracing is widely practiced.

FARM MACHINERY

CORN-BORER CONTROL

In the plow studies special emphasis has been placed on attachments to aid in producing better coverage of stalks. The scraping trash shield of floating type, which aids in effecting practically complete trash coverage, has been developed as a result of these studies. Three manufacturers have made especially shaped plow bottoms according to designs dictated by field tests.

A 3-row stalk shaver attachment has been developed for use on a single-row corn cultivator. This implement is light in draft, easy to maneuver, and performs satisfactorily. A 4-bar side-delivery rake fitted with specially constructed flexible teeth has been built for windrowing cornstalks. Field tests show that it does a very clean job of raking.

Work is in progress on stalk loaders. The rake-bar type and the combination cylinder and rake bar type of hay loader, after considerable alteration to meet the requirements, have given encouraging results in preliminary trials. Further studies have been made of baled whole and shredded stalks to note the effect of different baler pressures on borer mortality and also the keeping properties of the stalks.

Spur gear tooth crushing rolls have been installed on a 2-row corn picker to crush the borers in the stalks as the corn is picked. Preliminary tests give considerable promise.

A stationary-knife, low-cutting attachment has been worked out for the field-silage harvester. Work is under way on the construction of a standing-stalk chopper based on the silage-harvester principle.

Laboratory tests were continued on studies of the tolerance of free larvæ and borers in stalks to steam, oil flame, and electric oven. Exhaustive tests were made with a portable steaming unit, which was found to be unwieldy and impracticable as a corn-borer-control weapon.

A mobile burner of the pulled, hooded-flame type has been developed after much experimentation with various open-flame types. This hooded machine produces a high-temperature flame and is little affected by side winds. Little deterioration of the special-alloy hood plates has been noted after long periods of operation. One of these

burners was used effectively in California for combatting the pea aphis in alfalfa. Work is being done on the development of a satisfactory low-pressure fuel nozzle to replace the high-pressure nozzle now in use. An exposed-flame, regenerative type of burner unit developed for use in garden patches and fence corners has given fair results in preliminary trials. This is a 1-man outfit and is supplied with fuel oil at low pressure through a hose from a pump driven by a small engine.

Studies of plowing and corn-borer control machinery are being carried on in cooperation with the Illinois and Pennsylvania agricultural experiment stations.

A bulletin has been published on the stationary-knife, low-cutting attachment for corn binders and another on the sled-type stalk shaver. The manuscript for a bulletin dealing with the care and operation of husker-shredders in corn-borer-infested areas has been prepared.

Experimental work has been started on the Berkley, Mass., farm recently acquired by the Plant Quarantine and Control Administration and jointly operated by the Bureau of Public Roads, Plant Quarantine and Control Administration, and the Bureau of Entomology. Here opportunity is afforded to experiment with machinery under typical New England conditions.

CONTROL OF THE PINK BOLLWORM

Tests of a small hammer-mill type of feed grinder at Tallulah, La., and Tlahualilo, Mexico, in connection with studies of gin-trash disposal of pink bollworm control, have shown that practically 100 per cent pink bollworm mortality can be attained by using a fairly large sized grinding screen which allows ample capacity to care for a 6-stand gin when ginning picked cotton.

The cultural control investigations in pink bollworm investigations carried out at Presidio, Tex., confirm the outstanding conclusion of the first year's work; namely, that plowing about 6 inches deep followed immediately by irrigation gives practically complete pink bollworm mortality. Many of the other 90 plowing and irrigation combinations show, to date, very promising results, although compilation of the data has not yet been completed.

ARTIFICIAL DRYING OF GRAIN

This project is a part of a general study conducted for a few years past in cooperation with the Bureau of Plant Industry and the Bureau of Agricultural Economics on the use of the combined harvester-thresher. Studies were made of a commercial grain drier located at Parshall, N. Dak., and information was obtained regarding the power, labor, and fuel requirements for drying wheat and rye and the quality and conditions of the grain before and after drying. It was found that the operating expenses of the drier were small in comparison with the increase in market value of the grain due to the reduction in moisture content, but that unless a large quantity of grain could be dried each season, interest on the investment and depreciation would make the cost excessive. A manuscript based

on the results obtained at Parshall, N. Dak., has been submitted for publication.

Similar studies have been made on commercial driers located at Beaumont, Tex., and De Witt, Ark., in connection with the artificial drying of rice. A preliminary report has been issued on rice drying.

COTTON-DRYING EQUIPMENT

Under the supervision of the division of agricultural engineering, cotton driers were installed upon a number of plantations.

Plans for all-steel cotton driers were developed, and the construction of two such driers was begun for plantations at Heathman and at Lyon, Mississippi. The construction of all-steel driers was undertaken by two of the largest manufacturers in the cotton-ginning field. Assistance was requested by these concerns, and the division, in addition to supplying technical information, also aided in the conduct of special factory tests.

COTTON INVESTIGATIONS IN THE MISSISSIPPI DELTA

At the request of prominent planters and members of the Staple Cotton Cooperative Association of Greenwood, Miss., investigations were made in connection with the ginning of over 50,000 bales of staple cotton, the grade, color, and preparation of which had been lowered as a result of undetermined causes. Cotton gins were examined; arrangements of machinery were planned; methods of handling from field to gin were investigated; and an extensive canvass of gins and plantations was made in the districts of Greenwood, Clarksdale, and Greenville, Miss. About 40 combinations of standard and home-made ginning machinery were found, each having possible bearing upon the quality of the ginned fiber.

Many of the gins were found to be deficient in cleaning and extracting equipment, but the investigations disclosed that many of those best equipped had been turning out both inferior and superior work under identical operating conditions. It was found that the inferior work was accomplished on poorly conditioned seed cotton, while superior work was done where the seed cotton had been properly conditioned. This indicates the importance of satisfactory preliminary conditioning (i. e., drying and curing) of the seed cotton before it is brought to the gins, and confirms the need of suitable driers and conditioners, especially where the early green cottons are rushed to the gins, or where the late season and unfavorable weather necessitate rough picking of the crop.

COTTON-GINNING AND FIBER INVESTIGATIONS

A series of harvesting, ginning, drying, and fiber studies was undertaken in cooperation with the Bureau of Agricultural Economics and the Mississippi Delta Experiment Station at Stoneville, Miss. Cotton of similar certified breed and growth was harvested during four distinct periods of the season. Portions of these pickings were ginned after having been conditioned in several ways. Fiber samples were obtained from the ginnings upon each lot. The results will be tabulated and analyzed.

A very important series of tests was made at the test plants of some of the principal cotton-ginning manufacturers in cooperation with the division of cotton marketing, Bureau of Agricultural Economics. At Prattville, Ala., and at Atlanta, Ga., these tests were made upon short-staple and staple cottons under variable conditions of saw speed, roll density, etc. Preliminary study of these results, together with the extensive fiber investigations previously carried out by the Bureau of Agricultural Economics, indicate the need for a ginning and fiber laboratory in which the many unknown features of quality ginning can be investigated.

FERTILIZER DISTRIBUTORS

Fertilizer distributors for cotton now on the market differ greatly in uniformity of distribution, accuracy of obtaining and maintaining desired rates of application, and the placement of fertilizer in relation to the seed. Investigations made last year indicated that the germination and yield of cotton are greatly affected by the placement of the fertilizer, particularly on sandy soils.

To obtain fundamental information which will assist in the development of more efficient fertilizer distributors, a study is in progress, in cooperation with the Bureau of Chemistry and Soils, the joint committee on fertilizer application, and Clemson Agricultural College and Experiment Station (South Carolina), of machine placement and distribution of fertilizers for cotton. A special machine has been used to apply the fertilizers accurately at desired rates in various positions in relation to the seed and with different degrees of irregularity of distribution. The fertilizers were applied and the seed planted on three types of soils in South Carolina in the spring of 1930, and the effects on germination, early bloom, and yield will be recorded at the proper intervals. Tests on machine placement of fertilizer materials applied as a side dressing to cotton at thinning time are also in progress.

FARM-LAND DEVELOPMENT

It is quite generally recognized that before much reduction can be made in the general costs of crop production modern farm machinery must be utilized to the greatest extent possible. However, not all farms are adapted to the use of such machinery. In all parts of the country there are farms on which the fields are small and irregular, containing stumps or stones, wet spots, meandering streams, gullies, or straggling bodies of timber. Under such conditions modern machinery can not be used profitably. Investigations which have for their object the determination of the net benefits to be had on typical farms through a better physical development have been initiated in North Carolina and will be extended to other States.

Investigations of development work looking to more efficient methods have been continued, mainly in cooperation with various State agencies. In such cooperative work in Minnesota, it has been found that broadcast burning can be used to great advantage in

clearing land of standing brush. Such fires can be controlled and safely used by back-furrowing and by using simple water sprinklers. A low humidity is necessary for a good fire, and burning in the fall has not been as successful as spring burning. A project to determine the costs of all the various operations in clearing land of brush and stumps on each of the four principal soil types of northern Minnesota was completed during the year. In a cooperative project in Pennsylvania the possibilities of raising buried bowlders to the surface of the ground with large plows and blasting them were investigated and methods and costs determined. The experimental work in the use of poisons for killing trees and brush was continued in an effort to find a poison and method of poisoning which would be effective on all species of growth and under a wide variety of conditions.

Cooperative assistance in the agricultural-engineering features of surveys made for the purpose of classifying land according to its utility was furnished to the Bureau of Agricultural Economics and the State of West Virginia.

FARM STRUCTURES

GRAIN STORAGES

Increased facilities for the farm storage and handling of small grains in bulk have become a necessity because of the growing use of the combine harvester in many grain-producing areas, the present practice of paying premiums for wheat of high protein content, and the economic waste incident to the marketing of grain containing foreign material or dockage. Heavy losses due to the heating of grain in bins, to rodents, to excessive labor in handling, and to rapid deterioration may be attributed to improper design and construction of grain storages. Because of the lack of authoritative information regarding the best practices in grain-storage design and construction an investigation was made, and the results were published in a bulletin prepared in cooperation with the Bureau of Agricultural Economics. A subsequent study of the storage of corn and small grains was begun.

GREENHOUSE HEATING

The study of greenhouse heating was brought to a close, and the results are being prepared for publication. The data presented should be of material assistance to small owners of commercial greenhouses and to such local heating contractors as are unfamiliar with greenhouse heating problems.

STRUCTURES RESEARCH SURVEY

The many problems related to the design and construction of farm buildings of all kinds offer a rich field for research. Since farm buildings for the most part must be fabricated on the farm without the assistance of engineer or architect, it is evident that research in

this field must be conducted by public agencies. The facilities for making such investigations have been and are very limited, being entirely lacking in some of the State institutions. In view of the urgent need of research in farm structures, a survey was undertaken with the purpose of ascertaining what research activities are in progress throughout the country, what facilities are available, and what problems are awaiting solution as the basis for a national program of coordinated effort in structures research so administered as to stimulate activity, bring into action all available agencies and resources, and correlate and disseminate results. The field work of the survey has been practically completed during the year. There remains the preparation of a report and the formulation of a program of further procedure.

SEPTIC TANKS

The purpose and functioning of a septic tank are quite generally misunderstood. Because of this misunderstanding and the poor results so often obtained, a survey was made of a large number of installations in order to obtain first-hand information regarding the design and operation of various types of tanks and the causes of failures. The data obtained are yet to be analyzed, but it is quite evident that much of the dissatisfaction reported is due to neglect of the system and that regular, periodic removal of the sewage solids is essential to satisfactory performance. Recommendations based on the results of the survey should be of value to many rural-home owners.

SERVICE WORK

The service rendered other bureaus of the department greatly exceeded in volume that of the preceding years. The following partial list of such projects shows the wide scope of the activities which the bureau is called on to undertake.

Plans and specifications were prepared for a new shop and office building, a combined bulb storage and nursery laboratory, and three head houses for the Arlington Experiment Farm. Plans and specifications were also prepared for a zoological laboratory for the Beltsville Experiment Farm.

The necessary calculations were made and specifications prepared for about 15 refrigerating plants. Most of these plants were intended for use in investigational work and hence called for special design.

Calculations were made to determine the capacity of seven boiler plants, and in some instances specifications were prepared for the boilers.

Calculations and the layout of wiring were made for two high-tension electrical distribution systems. Specifications were drawn for electric motors, meters, heaters, isolated generating sets, etc., and calculations were made for electric heaters, incubators, and water-distilling apparatus for laboratories.

Four temperature-control systems were designed for as many different bureaus.

Specifications have been prepared for concrete mixers, gas engines, machine tools, and other miscellaneous equipment.

A dam designed by this bureau for the Bureau of Biological Survey was completed at the Wind Cave Game Preserve in South Dakota. A migratory-bird refuge, on the design of which the division furnished assistance is now under construction by the same bureau at the mouth of Bear River, Utah, and preliminary investigations have been made for a similar refuge in Oregon.

Plans and specifications were prepared for a small reservoir to be built in Wyoming for the Bureau of Plant Industry.

Some service work has also been performed for the State, Interior, Treasury, and Post Office Departments.

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